ECONOMIC FEASIBILITY ANALYSIS

of proposed **modelling scenarios for mitigating and adapting to the effects of climate change in the agriculture sector (viticulture)** in the Vardar Planning Region

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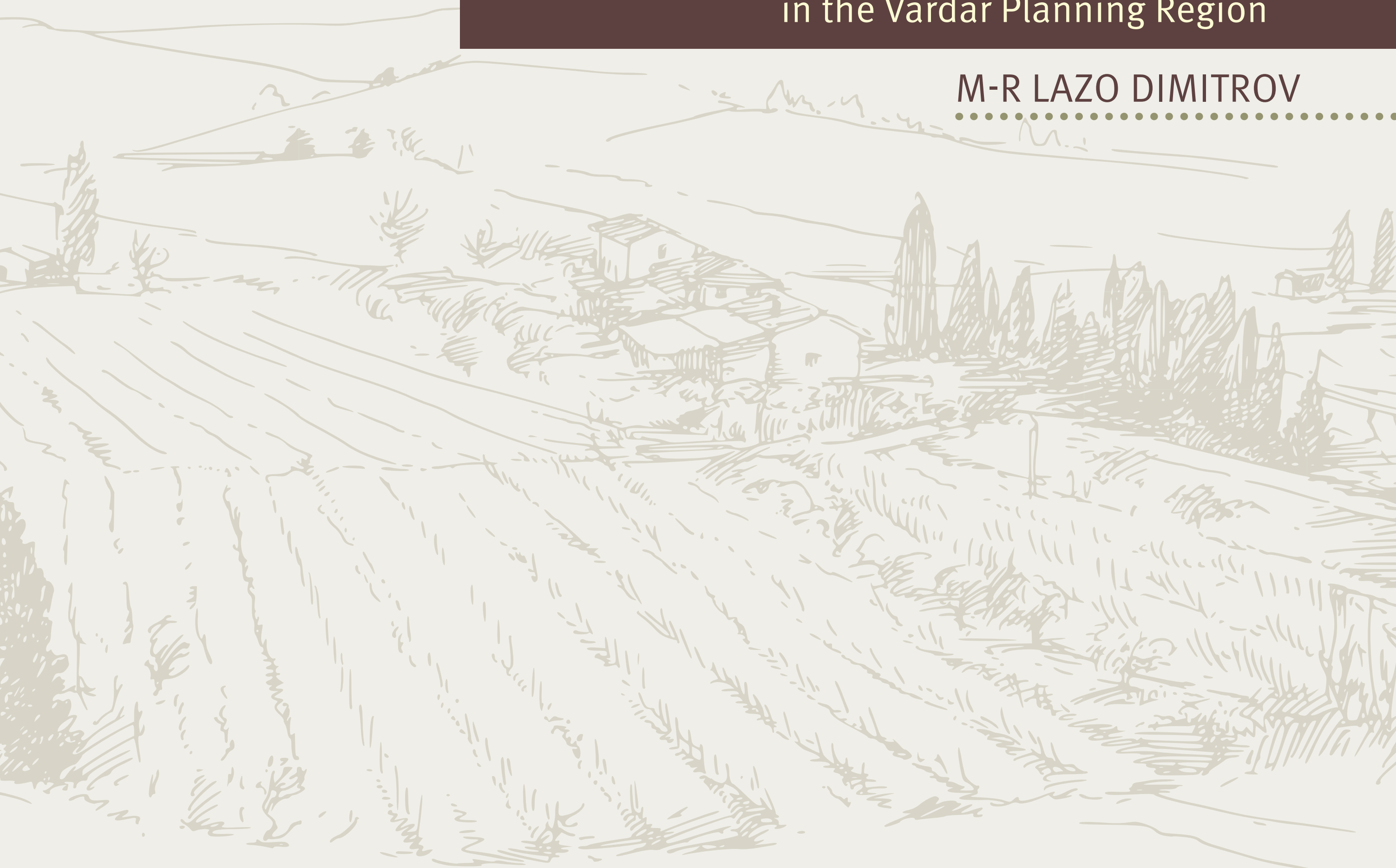

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1. BACKGROUND

Acknowledging the significance of the challenges and risks related to climate change and the need to take effective actions to mitigate these risks, the country ratified the UN Framework Convention on Climate Change (UNFCCC) on December 4, 1997 (Official Gazette of the Republic of Macedonia – International Agreements 61/97). The First National Communication was submitted to the UNFCCC Secretariat in March 2003 and the Second National Communication (SNC) was submitted in January 2009. The country is currently working on the preparation of its Third National Communication.

During the second half of 2012, the UNDP Country Office in Skopje conducted the first phase of the Governance Assessment (GA) of Local Action for Climate Change (CC). The objective of this first phase was to develop a methodology for assessment rather than to provide a comprehensive governance assessment.

Phase II of the assessment is supported by the UNDP Oslo Governance Centre and is being implemented within the framework of the 'Local Action for Inclusive Development – Local Development Programme' project being undertaken by the UNDP CO in Skopje for the Vardar and South–East Planning Regions.

Within this second phase of the project, a special focus is placed on conducting an integrated cross-sectoral assessment of vulnerability and adaptation to climate change. In particular, this assessment focuses on the relations between water resources, agriculture, health, and disaster risk reduction in the Vardar Planning Region.

The Biophysical Model Application (BioMA) was introduced as a new and innovative approach for developing baseline and modelling scenarios (i.e. scenarios with/without adaptation measures) for viticulture in the Vardar Planning Region.

1.1 Assignment logic

The main objective of the assignment was to carry out an economic feasibility analysis of proposed modelling scenarios for mitigating and adapting to climate change in the agriculture sector (viticulture) in the Vardar Planning Region and to recommend appropriate measures.

The methodology employed replicated that used in the South-East Planning Region.

1.2 Assignment objectives

The National Expert was responsible for the completion of the following tasks:

- Assessing the economic feasibility of the baseline and developed modelling scenarios (with/without adaptation measures) using BioMA for proposed specific scenarios for the Vardar Planning Region up to the year 2030;
- Preparing cost-benefit analyses of the proposed measures for mitigating and adapting to the negative impacts of climate change;
- Assessing the economic feasibility of upgrading and/or investing in the implementation of the scenarios and proposed adaptation measures;
- Identifying the break-even point and assessing the sustainability of the proposed scenarios, finding the point of balance between the costs and benefits and returns on investment;
- Preparing a report summarizing the main findings of the economic feasibility of the measures in the agriculture sector (viticulture), including recommendations as to which measures are most economically viable to implement.

2. METHODOLOGY AND APPROACH

The assessment of the economic feasibility of proposed climate change modelling scenarios in the agriculture sector was performed through Cost-Benefit Analysis and Break-Even analysis.

2.1 Methodology for Cost-Benefit Analysis

Cost-benefit analyses were performed on the proposed measures for mitigating and adapting to climate change. Cost-benefit analysis assesses the extra costs and benefits of the proposed scenarios.

The main hypothesis is that the proposed scenarios will generate extra costs but will also generate extra revenues. The extra gross margin is calculated as the difference between extra revenue and extra costs.

This approach was based on the partial budgeting calculation of the differences between the baseline scenario, the developed modelling scenarios and specific proposed scenarios for the Vardar Planning Region up to year 2030. Partial budgeting takes into account extra costs and income arising from the proposed changes in agro-management scenarios compared with the baseline scenario.[1] Extra costs are incurred either by the adoption of proposed agro-technical measures or by reduced income. The extra costs generated as a result of the proposed scenarios include:

- The need for additional irrigation water
- The investment impact on the price of water
- Higher production costs arising from increased transport costs for production at higher altitudes
- Depreciation of the investment assets of the adaptation measures (i.e., dams, irrigation systems, UV nets and soil preparation)
- The annual costs of maintaining the investment assets of the adaptation measures

[1] The baseline scenario (SC0) corresponds with traditional crop management, i.e., without irrigation, and predicts a decrease in yields as a result of climate change. The extra costs for SC0 are thus calculated as the decrease in yield compared with the yield in baseline year 2000.

Extra income is generated as a result of reduced costs, increased yields, and higher prices for yields. The extra income generated by the adaptation measures proposed in the various scenarios includes:

- Additional yield (income from sold yield) compared with the baseline scenario; and
- Higher prices for yields as a result of improved quality and reduced sunburn spots on grapes.

Based on extra costs and income, the extra gross margin is calculated for all proposed scenarios. The gross margin is calculated per hectare and per year.

The cost-benefit analysis is based on different assumptions for different scenarios. The first assumption (Hypothesis 1) is that farmers already have the necessary assets and preconditions (irrigation skims, UV nets, prepared soil and parcels) and thus no additional investment is required for adaptation. The second assumption (Hypothesis 2) is that farmers will need to invest in irrigation systems, UV nets or land preparation in the scenario for production at higher altitudes. The last presumption (Hypothesis 3) is that farmers will additionally need to invest in water supply systems (dams, reservoirs, wells).

2.1.1 Hypothesis 1. All assets and preconditions exist

Hypothesis 1 presumes that farmers already have irrigation skims, UV nets, prepared soil and land parcels, and access to water. Any extra costs of implementing the proposed adaptation measures will thus be generated only by additional costs for irrigation water and higher costs of production due to increased transport costs at higher altitudes.[2]

2.1.2 Hypothesis 2. Water-collecting systems (dam/reservoir) exist but investment is needed for other assets

Hypothesis 2 presumes that farmers have access to water but need to invest in irrigation skims and UV nets, and that additional investments are needed for land preparation and parcelization in hilly areas at higher altitude. Besides the costs in Hypothesis 1, additional costs will be incurred by annual depreciation and the maintenance of irrigation systems, UV nets and extra investment for land preparation at higher altitudes.[3]

[2] For more details and references about the prices used and the assessment normative, see Annex 1. Methodology and Assessment Normative.

[3] For more details on prices and the assessment normative, see Annex 1. Methodology and Assessment Normative.

2.1.3 Hypothesis 3. No water-collecting systems (dams/reservoirs) or irrigation systems exist and investment is needed

Hypothesis 3 presumes that farmers do not have access to water and must invest in the construction of a water-collecting system. Besides the costs in Hypothesis 2, additional costs will be incurred through annual depreciation and the maintenance of the water-collecting system.[4]

2.2 Methodology for Assessing the Economic Feasibility of Investment

The economic feasibility of the investments required by the proposed scenarios was assessed on the basis of Net Present Value (NPV), the Internal Rate of Return (IRR) and the Payback Period (PP).

2.2.1 Net Present Value

The Net Present Value of the different scenarios was calculated based on the future value of annual cash flows discounted at the present time. The NPV is the calculation of the money value, taking the time factor into consideration. Actually, the NPV calculates the present value of the money from the future period, taking into consideration time and inflation.

n – period (year)

i – interest rate (discount factor)

PV – present (discounted) value

$NPV = PV_1 + PV_2 + .. + PV_n$

The following values were used in the analysis:

n = 10 years (2015–2025)

n = 35 years (2015–2050)

i = 6%

4 The dam capacity is based on the irrigation volume of the scenario.

The estimation period was based on the expectation that the findings and recommendations will be promoted in 2014 and that the actual implementation of the proposed scenarios will commence in 2015.

2.2.2 Internal Rate of Return

Internal Rate of Return (IRR) is an indicator of investment efficiency and represents the interest rate of the investment. The IRR is the interest rate for which the NPE value is zero (0). The investment is acceptable when the IRR is higher than the minimum acceptable interest or cost of capital.

2.2.3 Payback Period

Payback Period (PP) is the period of time needed to recoup the investment. It is calculated based on cash flows. The payback period is the year when the result of the cumulative cash flows has a positive value.

2.3 Methodology for Break-Even Analysis

Break-even analysis was performed for each hypothesis, scenario and period. The break-even point is when total costs are equal to total revenues. Break-even analysis should give the minimum value for different indicators in order to achieve economic feasibility. Break-even analysis was performed for the selling price of grapes, the yield quantity, the price of water and the investment value. To some extent, break-even analysis can be perceived as a risk analysis tool and as a vulnerability assessment of the proposed scenarios.

[3. RESULTS]

3.1 Cost-benefit analysis

In general, the proposed changes to agro-management practices achieve better results than traditional production practices, i.e. without irrigation, in the baseline scenario (SC 0).[5] The only exceptions are the adaptation measures requiring the use of UV nets and those involving an increase in altitude of 500 m in table grape production.

3.1.1 Cost-benefit analyses of scenarios for wine grape production

Cost-benefit analyses of the seven proposed scenarios were conducted for wine grape production.[6] All scenarios incur additional costs for irrigation. Differences in the costs of the scenarios arise from differences in irrigation volume, water price, yields, and the type and value of investments involved. Extra production costs are expected to be incurred with the altitude increase involved in scenarios 2 and 3 as a result of extra costs for spending on fuel and transport at higher altitudes. Extra costs are incurred by the labour needed for furrow construction in scenarios where irrigation is done by furrow. Extra income is generated as a result of additional yield (income from sold yield) compared with the baseline scenario. Extra income is calculated based on the average selling price of wine grape at EUR 0.24 (MKD 15).

[5] The presented results refer to the worst case, Hypothesis 3, which assumes farmers must invest in water-collecting systems (tanks/dams), irrigation systems, land construction and UV nets. This is also the most probable case given that only 59% of vineyards in the Vardar region have irrigation systems (49% at national level), only 30% of all farmers in the country have irrigation equipment, and the use of UV nets is insignificant. According to the State Statistical Office of the Republic of Macedonia, around 70% of farmers have access to water (for more details, see Annex 4. Agriculture irrigation). However, it is highly probable that farmers in the future will face water shortages and therefore investment in water-collection systems will be necessary to meet this need for water and to ensure timely and quality irrigation.

[6] In total, ten scenarios are presented in the study. However, the altitude and UV net scenario 1 are identical with irrigation scenario 1, which involves irrigation by furrow and an irrigation volume of 160 mm. These scenarios are not included in the analysis as separate scenarios because the result gained from irrigation scenario 1 is also applicable and relevant.

Table 1. Main assumptions and indicators for wine grape production

			Irrigation		Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160mm	Drip 120mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
INVESTMENT								
Adaptation investment		Furrow	Drip system		Land construction Furrow		UV net Furrow	
Investment value [EUR]		0	2.200	2.200	1.500	2.500	12.000	12.000
Tank/Dam capacity [mm]		160	160	120	160	160	160	160
Dam investment value [EUR]		1.723	1.292	1.723	1.723	1.723	1.723	1.723
Irrigation								
Irrigation [number x mm]	Бр.	2 x 80	2 x 20 3 x 40	3 x 40	2 x 80	2 x 80	2 x 80	2 x 80
Irrigation volume [mm/ha]		160	160	120	160	160	160	160
Water price [EUR/m3]		0,075	0,027	0,027	0,075	0,075	0,075	0,075
Extra costs								
Higher altitude transport costs					200	400		
Labour for furrow construction		450			450	450	450	450
YIELDS								
Yields difference 2025 [kg/ha]	-1.063	2.745	3.409	3.192	3.721	979	3.629	2.490
Yields difference 2050 [kg/ha]	-932	3.842	4.695	4.355	4.997	2.681	4.929	3.750

In the period from 2015 to 2025, drip irrigation with 160 mm volume gains the highest result. Implementing the proposed agro-management practices from this scenario will result in additional annual profit of EUR 545 per hectare.

The worst results are gained in SC 3 with the use of UV nets for a 5°C decrease in temperature. The use of UV nets in the production of wine grapes with this scenario generates annual losses of EUR -1,238 per hectare. This loss is higher than the loss incurred in the baseline scenario (SC 0) of production without irrigation, which shows negative results and a loss of EUR -263 on an annual basis. The result obtained with this scenario are still less negative, however, than those incurred with the scenario for an altitude increase of 500 m (SC 2) and the use of UV nets for decreasing temperature by 2°C and 5°C (SC 2 and 3).

Table 2. Annual cost-benefit results for wine grape production (from 2015 to 2025 in EUR/ha)

			Irrigation		Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160mm	Drip 120mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
Irrigation costs	0	120	43	32	120	120	120	120
Higher altitude costs					200	400		
Labour for furrow construction		450			450	450	450	450
Maintenance			20	20			40	40
Depreciation	0	17	164	160	60	89	1.217	1.217
Total extra costs	0	587	226	211	830	1.059	1.827	1.827
Extra revenue	-259	669	832	779	908	239	885	607
Profit before taxes	-259	82	605	567	78	-820	-942	-1.220
Taxes	-4	8	61	57	8	-12	-14	-18
Profit/loss	-263	74	545	510	70	-832	-956	-1.238

The trend of impact of the adaptation measures and results continues in the period from 2025 to 2050, with the effects of the measures intensifying and with results getting higher. The highest result is still generated with the implementation of SC 2, which recommends drip irrigation at 160 mm volume and generates extra profit of EUR 827.

The most negative results are still gained by SC 3 with the use of UV nets to decrease temperature by 5°C. The extra loss of this scenario is EUR -926. However, the loss in the period 2025–2050 is lower than in the period up to 2025.

The baseline scenario (SC 0) incurs a loss of EUR -231 on an annual basis. The result from this scenario is less negative than from the scenario for an increase in altitude of 500 m (SC 2) and the use of UV nets for decreasing temperature by 2°C and 5°C (SC 2 and SC 3).

Table 3. Annual Cost-benefit results for wine grape production (from 2025 to 2050 in EUR/ha)

			Irrigation		Altitude		UV net	
Adaptation measure	NO	Furrow 0m / 0ºC	Drip 160mm	Drip 120mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
Total extra costs	0	587	226	211	830	1.059	1.827	1.827
Extra revenue	-227	937	1.145	1.062	1.219	654	1.202	915
Profit before taxes	-227	350	919	851	389	-405	-625	-912
Taxes	-3	35	92	85	39	-6	-9	-14
Profit/loss	-231	315	827	766	350	-411	-634	-926

3.1.2 Cost-benefit analyses for table grape production

Cost-benefit analyses for table grape production were performed on the 7 proposed scenarios.

All scenarios incur additional costs for irrigation. Differences in costs arise from differences in irrigation volume, water price, yields, and the type and value of investments involved.

Extra production costs are expected to arise from the altitude increase involved in scenarios 2 and 3 as a result of extra costs for transport and fuel spend. Extra costs are generated by labour needed for furrow construction in scenarios where irrigation is done by furrow.

Extra income is generated as a result of additional yield (income from sold yield) compared with the baseline scenario. In the case of UV net use, additional income is gained from an increase in grape quality. The additional income is calculated based on the increased price of the yield as a result of increased quality and reduced sunburn spots.[7] The extra income is calculated based on the EUR 0.41 (MKD 25) average price of table grape.[8]

[7] The use of UV nets reduced sunburn spots on table grapes by 4% according to preliminary results from demonstration trials.
[8] Reducing sunburn spots improves the quality of grapes, increasing their selling price by EUR 0.2.

Table 4. Table grape main assumptions and indicators

			Irrigation		Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160mm	Drip 120mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
INVESTMENT								
Adaptation investment		Furrow	Drip system		Land construction Furrow		UV net Furrow	
Investment value [EUR]		0	2.200	2.200	1.500	2.500	12.000	12.000
Tank/Dam capacity [mm]		160	160	120	160	160	160	160
Dam investment value [EUR]		1.723	1.292	1.723	1.723	1.723	1.723	1.723
Irrigation								
Irrigation [number x mm]	No	2 x 80	2 x 20 3 x 40	3 x 40	2 x 80	2 x 80	2 x 80	2 x 80
Irrigation volume [mm/ha]		160	160	120	160	160	160	160
Water price [EUR/m3]		0,075	0,027	0,027	0,075	0,075	0,075	0,075
Extra costs								
Higher altitude transport costs					200	400		
Labour for furrow construction		450			450	450	450	450
YIELDS								
Yields difference 2025 [kg/ha]	-1.096	5.194	6.893	6.316	7.887	2.352	7.686	4.982
Yields difference 2050 [kg/ha]	-948	6.512	8.719	7.740	9.432	4.565	9.293	6.576
Increased quality 2025 [kg/ha]							1.313	1.205
Increased quality 2050 [kg/ha]							1.339	1.231

In the period from 2015 to 2025, the highest result is gained with production at higher altitude SC 2, which recommends using drip irrigation of 160 mm volume. Implementing the proposed agro-management practices from this scenario will result in additional annual profit of EUR 2,318 per hectare.

The worst results were gained in baseline SC 0 without irrigation: the production of table grapes without irrigation incurs annual losses of EUR -452 per hectare.

Scenario 3, involving a 500 m increase in altitude, shows negative results and incurs losses on an annual basis. However, this result is still less negative than the baseline scenario without irrigation and with no change in production practices.

Table 5. Annual cost-benefit results for table grape production (from 2015 to 2025 in EUR/ha)

			Irrigation		Altitude		UV net	
Adaptation measure	NO	Furrow 0 m /0°C	Drip 160mm	Drip 120mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
Irrigation costs	0	120	43	32	120	120	120	120
Higher altitude costs					200	400		
Labour for furrow construction		450			450	450	450	450
Maintenance			20	20			40	40
Depreciation	0	17	164	160	60	89	1.217	1.217
Total extra costs	0	587	226	211	830	1.059	1.827	1.827
Extra revenue	-446	2.111	2.802	2.568	3.206	956	3.391	2.270
Profit before taxes	-446	1.524	2.576	2.356	2.376	-103	1.564	443
Taxes	-7	152	258	236	238	-2	156	44
Profit/loss	-452	1.372	2.318	2.121	2.138	-104	1.408	399

The trend of adaptation measures having a positive impact and positive results continues in the period from 2025 to 2050, with more intensive effects from the measures and higher results. The highest results will be generated with the implementation of SC2, which recommends using drip irrigation with 160 mm. The use of drip irrigation will generate extra profit of EUR 2,986.

The most negative results are still gained without irrigation in SC 0. The extra loss from yield reduction will be EUR -391.

The increase in altitude of 500 m in SC 3 gains positive results in the period from 2025 to 2050, compared with the previous period when the results were negative. This scenario in this period generates extra profit of EUR 718.

Table 6. Annual cost-benefit results for table grape production (from 2025 to 2050 in EUR/ha)

			Irrigation		Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160mm	Drip 120mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
Total extra costs	0	587	226	211	830	1.059	1.827	1.827
Extra revenue	-385	2.647	3.544	3.146	3.834	1.856	4.050	2.923
Profit before taxes	-385	2.060	3.318	2.935	3.004	797	2.223	1.096
Taxes	-6	206	332	293	300	80	222	110
Profit/loss	-391	1.854	2.986	2.641	2.704	718	2.001	986

3.2 The Economic Feasibility of Investing

All except one of the proposed scenarios show positive economic results in cases when no investment is needed. There are four sustainable scenarios that justify investing in adaptation measures in wine grape production.

For table grape production, there are five sustainable and financially feasible scenarios for investment in adaptation measures. There are limitations in the case when farmers must invest in UV nets. In this case, only SC 2, which involves decreasing temperature by 2°C without investment in a water-collecting system, shows higher results compared to the baseline scenario without irrigation. However, this is not an economically feasible scenario because the net present value is negative.

3.2.1 The economic Feasibility of not investing

In the case when farmers do not invest in adaptation measures (drip system, soil preparation and UV net), all proposed scenarios (except SC 3 with a 500 m increase in altitude for wine grape production) show positive results and the NPV is positive. In the case of wine grape production, drip irrigation with 160 mm in SC 2 shows the highest NPV with EUR 12,049. The installation of UV nets for decreasing temperature by 2°C involved in SC2 has the highest NPV, with EUR 40,524 in the case of table grape production.[9]

[9] The details are presented in Annex 3. Economic feasibility calculations.

Table 7. The economic feasibility of the proposed scenarios in the production of wine grapes without investment in adaptation measures

			Irrigation		Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160mm	Drip 120mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
PP								
NPV	-3.584	3.018	12.049	11.305	3.796	-7.751	5.627	1.939
IRR								

Table 8. The economic feasibility of the proposed scenarios in the production of table grapes without investment

			Irrigation		Altitude		UV net	
Adaptation measure	NO	Furrow 0 m /0°C	Drip 160mm	Drip 120mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
PP								
NPV	-6.120	23.555	40.515	36.544	35.823	5.587	40.524	25.858
IRR								

3.2.2 Economic Feasibility of investment in adaptation measures

The best scenario is again that of drip irrigation with 160 mm in SC 2 for wine grape, when farmers have to invest in adaptation measures without investment in a water collecting system. The investment in this adaptation measure generates an NPV of EUR 5,852 and IRR 11.86%. The repayment of the investment will be achieved in 10 years, which is lower than the analysed period of 35 years. Investment in UV nets and an increase in altitude of 500 m is not economically feasible. The results from these adaptation measures are more negative than those of the baseline scenario.

Table 9. The economic feasibility of the proposed scenarios in wine grape production with investment in adaptation measures

			Irrigation		Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160mm	Drip 120mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
PP		1	10	10	11			
NPV	-3.584	3.018	5.852	5.108	2.358	-10.267	-41.134	-45.291
IRR		N/A	11,86%	11,19%	13,49%			

The 250 m increase in altitude involved in SC 2 is the best of the scenarios for table grape production. Investment in this adaptation measure generates an NPV of EUR 34,385 and an IRR 146.46%. Repayment of the investment will be achieved in one year, which is lower than the analysed period of 35 years.

Investing in UV nets to decrease temperature by 2°C and 5°C is not economically feasible. The results from the use of UV nets for decreasing temperature by 5°C are more negative than the baseline scenario. Still, the use of UV nets for decreasing temperature by 2°C incurs less negative financial results than the baseline scenario.

Table 10. The economic feasibility of the proposed scenarios in table grape production with investment in adaptation measures

			Irrigation		Altitude		UV net	
Adaptation measure	NO	Furrow 0 m /0°C	Drip 160mm	Drip 120mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
PP		1	3	3	1	14		
NPV	-6.120	23.555	34.319	30.347	34.385	3.130	-4.956	-19.622
IRR		N/A	37,98%	34,92%	146,46%	10,50%		

3.2.3 The economic feasibility of investing in water-collecting systems and adaptation measures

In wine grape production there is no significant difference when farmers need to additionally invest in a water-collecting system as compared to when they only need to invest in adaptation measures. Drip irrigation of 160 mm volume is the best scenario, while investment in UV nets and an increase in altitude of 500 m are not economically feasible. Investment in water-collecting systems generates additional costs and reduces the positive effects of the scenarios compared with investment only in adaptation measures.

Table 11. The economic feasibility of the proposed scenarios in wine grape production with investment in adaptation measures and a water-collecting system (dam/tank)

			Irrigation		Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160mm	Drip 120mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
PP		13	12	12	15			
NPV	-3.584	1.465	4.300	3.944	806	-11.848	-42.715	-46.872
IRR		10,17%	9,51%	9,42%	7,45%			

The situation is the same in the case of table grape production. An increase in altitude of 250 m is the best of the table grape scenarios, while investments in UV nets are not economically feasible.

Table 12. The economic feasibility of the proposed scenarios in table grape production with investment in adaptation measures and a water-collecting system (dam/tank)

			Irrigation		Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0ºC	Drip 160mm	Drip 120mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
PP		2	4	4	2	16		
NPV	-6.120	22.003	32.766	29.183	32.833	1.563	-6.508	-21.174
IRR	0,00%	80,69%	30,38%	29,39%	68,31%	7,65%		

3.3 Break-even analysis

Break-even analyses were performed for all scenarios to determine the number of indicators, minimum and maximum values for the economical feasibility of each scenario. The break-even analyses were performed in order to identify the minimum selling prices of yields, the maximum price of irrigation water, yields loss and the maximum value of investments in adaptation measures and water- collecting systems.

3.3.1 Break-even analysis for wine grape production

The most competitive scenarios for wine grape production are SC 1 and SC 2 with furrow and drip irrigation of 160 mm volume. Both scenarios can tolerate a decrease in the selling price of EUR 0.17 from the calculated EUR 0.24. Still, drip irrigation can afford the maximum price of irrigation water of EUR 0.28 per cubic meter, a price 10 times higher than the price used in the assessment. Additionally, this scenario can afford a maximum yields loss of 11%, or 3.9 years of complete yields loss.

The most sensitive scenario is that of an increase in altitude of 250 m. This scenario has the lowest flexibility with regard to fluctuation in the price of the irrigation water as compared to drip and furrow irrigation. At the same time, this scenario is the most vulnerable and a small reduction in yield can cause financial infeasibility. Financial infeasibility will be caused with a reduction in yield of 2%, or 1 year of complete yields loss in the analyzed period 2015-2050.

The UV net scenarios with an increase in altitude of 500 m require an enormous increase in selling price to become sustainable: The UV Net Scenario 3 can be financially viable if the selling price is EUR 1.36 or with an additional yield of 14,200 kg compared with the baseline; SC 2 demands a price of EUR 0.99 or an additional yield difference of 13,100 kg; and altitude SC 3 requires a selling price of EUR 0.72 or an additional yield difference of 3,500 kg.

Table 13. Break-even indicators for wine grape scenarios

		Irrigation		Altitude		UV net	
Adaptation measure	Furrow 0 m / 0ºC	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
Lowest Selling Prices	0,170	0,170	0,210	0,230	0,720	0,990	1,360
Highest Water Prices	0,240	0,280	0,150	0,120			
Max yields reduction	4%	11%	7%	2%			
Max years with yields lost	1,5	3,9	2,5	0,7			
Additional yield					3.500	13.100	14.200

3.3.2 Break-even analysis of table grape production

The situation is similar for table grape production. As with wine grape production, SC 1 and SC 2 with drip and furrow irrigation of 160 mm volume are the most competitive scenarios for table grape production. Both scenarios can tolerate a EUR 0.32 decrease in the calculated selling price of EUR 0.41, i.e., a price 4 times lower. Drip irrigation can afford the maximum price for irrigation water of EUR 1.9 per cubic meter, a price more than 70 times higher than the price used in the assessment. Additionally, this scenario can afford a maximum yields loss of 20%, or 6.9 years of complete yields loss.

Drip irrigation with 120 mm volume and a 250-metre increase in altitude are competitive scenarios. In some aspects, such as the yield loss, these scenarios perform even better than furrow irrigation and can bear higher yields losses annually.

The most sensitive scenario is that of an increase in altitude of 500 m. This scenario has the lowest flexibility with regard to fluctuations in the price of irrigation water, compared with drip and furrow irrigation. At the same time, this scenario is the most vulnerable and a small reduction in yield can cause financial infeasibility. Financial infeasibility will be caused with a reduction in yield of 1% or 0.5 years of complete yields loss.

The UV net scenarios require an increase in the selling price in order to become sustainable. Scenario 3 within the UV net scenarios can be financially viable if the selling price is EUR 0.67, or if there is an additional yield difference of 4,000 kg compared with the baseline. SC 2 demands a price of EUR 0.47 or an additional yield difference of 1,300 kg compared with the baseline.

Table 14. Break-even indicators for table grape scenarios

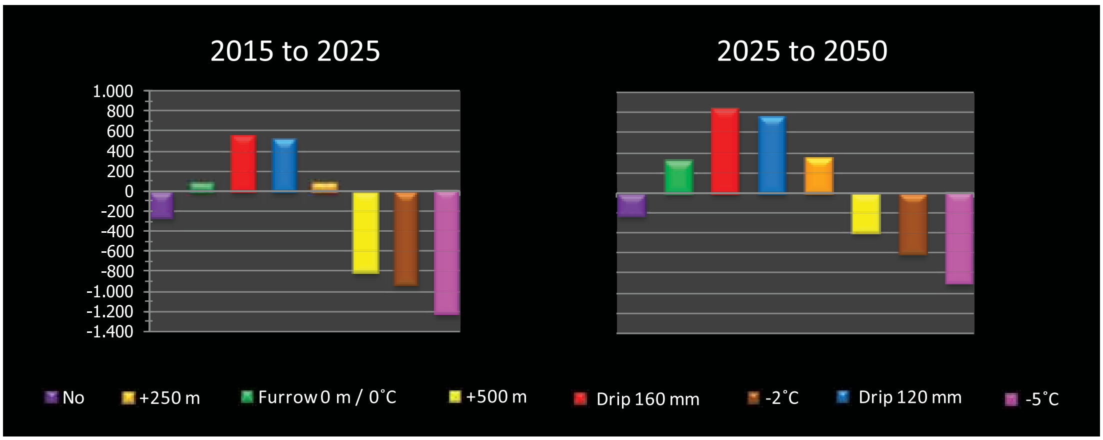
		Irrigation		Altitude		UV net	
Adaptation measure	Furrow 0 m / 0ºC	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
Lowest Selling Prices	0,090	0,090	0,120	0,120	0,380	0,470	0,670
Highest Water Prices	1,600	1,900	1,130	1,650	0,150		
Max yields reduction	14%	20%	17%	19%	1%		
Max years with yields lost	4,7	6,9	5,9	6,5	0,4		
Additional yield						1.300	4.000

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Wine grape conclusions

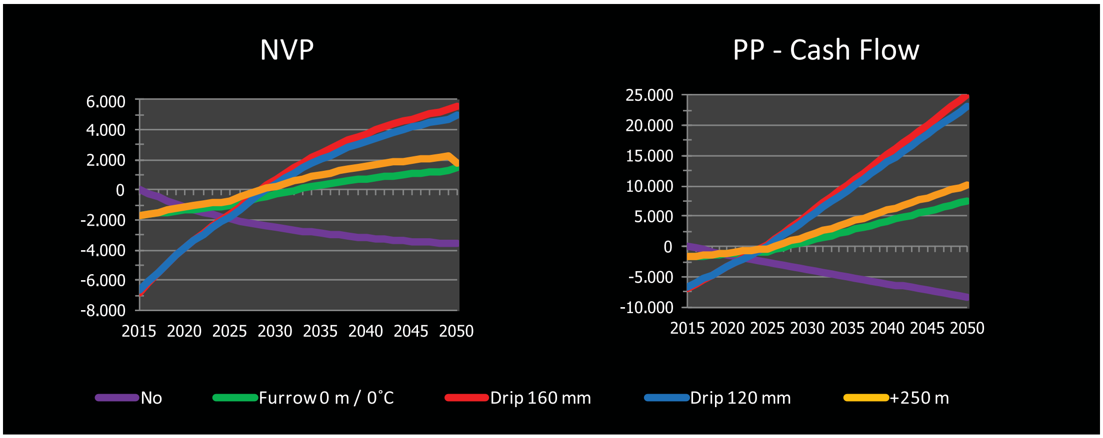
In the first analysis period, from 2015 to 2025, the proposed wine grape scenarios for irrigation and altitude change can easily counterbalance the negative effects of climate change. In the second period, from 2025 to 2050, the scenarios respond more intensively to climate change challenges and higher positive scenario results are achieved. Scenarios involving furrow and drip irrigation of 160 mm volume generate high profits. These are also the most competitive scenarios for wine grape production. These scenarios can tolerate a decrease in selling price, an increase in the price of irrigation water and yields loss. The worst scenarios are those involving the use of UV nets and a 500 m increase in altitude. These scenarios incur greater losses than the baseline scenario without irrigation and with no change of production technology.

Figure 1. Hypothesis 3. Cost-benefit profit results for wine grape production (in EUR)



The best scenarios for wine grape production when farmers have to invest in adaptation measures are those scenarios involving drip irrigation. These scenarios generate the highest NPV, the greatest cash flow and the fastest repayment of the investment. Investment in UV nets and an increase in altitude of 500 m are not economically feasible. These scenarios generate worse results than the baseline scenario without irrigation and without the implementation of adaptation measures.

Figure 2. Hypothesis 3. EThe Economic Feasibility of Investment in Scenarios for Wine Grape production, per year (in EUR)[10]



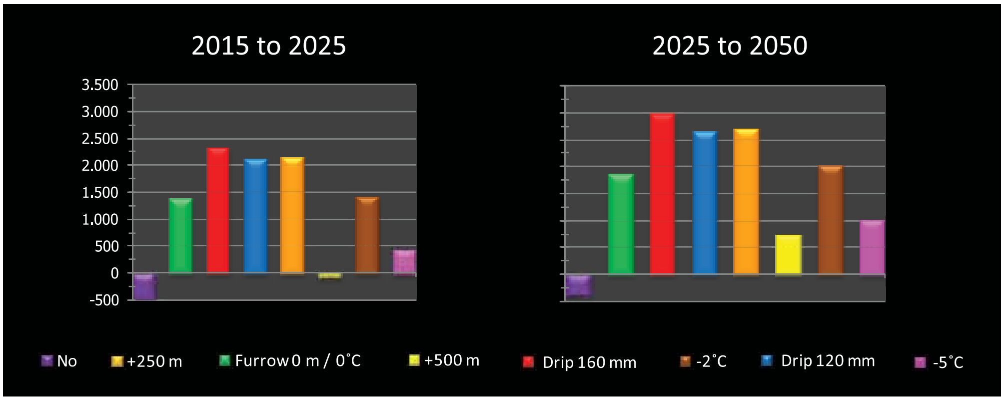
4.2 Conclusions relating to table grape production

In the first analysis period, from 2015 to 2025, the proposed scenarios for irrigation, altitude change and UV nets in table grape production can easily counterbalance the negative effects of climate change. In the second period, from 2025 to 2050, the scenarios respond more intensively to adaptation measures. As in the case of wine grape production, higher positive scenario results are gained in the period from 2025 to 2050.

The scenarios involving drip irrigation and an increase in altitude of 250 m generate high profits. Furrow and drip irrigation of 160 mm volume are the most competitive scenarios that generate the highest profits. These scenarios can tolerate a decrease in the selling price, an increase in the price of irrigation water and more or less, they can tolerate yields loss. Drip irrigation of 120 mm volume and an increase in altitude of 250 metres are also competitive scenarios. In some aspects, such as the yield loss, these scenarios perform even better. The use of UV net scenarios in table grape production generates profit.

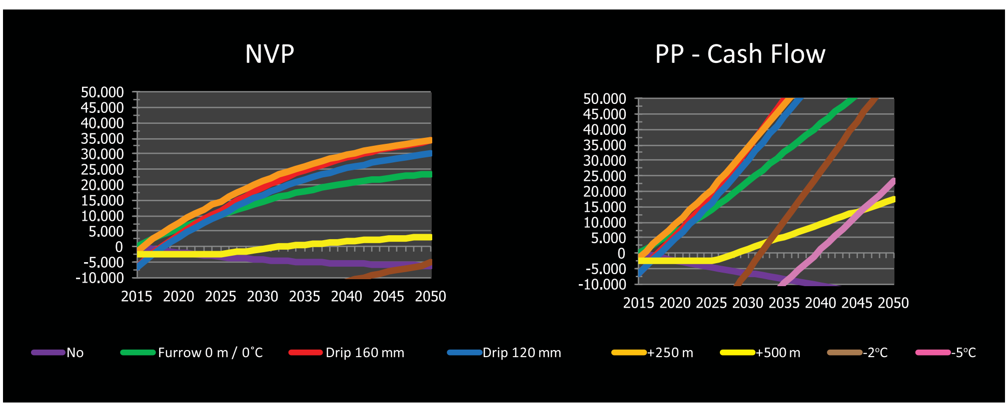
[10] The NPV and cash flow for investment in UV nets and a 500m increase in altitude are not presented because they have highly negative NPV and cash flow results at the end of the series.

Figure 3. Hypothesis 3. Cost-benefit profit results for table grape production (in EUR)



In cases when farmers have to invest in adaptation measures, an increase in altitude of 250 m is the best scenario for table grape production. This scenario generates the highest NPV and cash flow results and the fastest repayment on the investment. Scenarios involving investment in UV nets and an increase in altitude of 500 m are not economically feasible. These scenarios generate worse results than the baseline scenario without irrigation and without implementation of adaptation measures.

Figure 4. Hypothesis 3. The Economic Feasibility of Investment in scenarios for table grape production, per year (in EUR)[11]



[11] The NPV and cash flow for investment in UV nets and an increase in altitude increase of 500 m are not presented, as they have highly negative NPV and cash flow at the end of the series.

4.3 Recommendation

It is highly recommended that the following notes and recommendations be taken into consideration for the upcoming period:

- The presented results are based on the impact of adaptation measures on yield. Bearing in mind that grape prices and the purchase of grapes (especially wine grapes) are based on grape quality, including chemical content and sugar units, future research and analysis should be performed in order to evaluate the impact of climate change and adaptation measures on the chemical content of grapes.
- Although the use of UV nets shows negative results and is not economically feasible, it is important to emphasize that the benefits of such nets are only observed here through the aspect of temperature decrease, without taking into consideration the role that nets play in protection against hail. This is especially important for table grapes. According to the results, investment in UV nets for a decrease in temperature of 2°C requires an additional yield of 1,300 kg, while for a decrease in temperature of 5°C the necessary increase in yield would be 4,000 kg. If we convert these in yield loss from hail, it will take 1.3 years of complete yields loss in the first case and 4.6 years in the second case in order to achieve economical feasibility. It is highly plausible that hail will occur many times in a period of 35 years and thus UV nets will have a highly positive financial impact in table grape production. Still, it is recommended that this analysis be upgraded and repeated with risk data, hail occurrence frequency and occurrence probability.
- The analysis is based on constant prices, without taking into account the impact of climate change on the prices of water and grapes. It would be wise to upgrade and repeat the analysis once relevant research has been conducted into the impact of climate change on trends in the prices for water and grapes.
- The national support programme and financial support for introducing drip irrigation in wine grape production should continue. From the results of the scenarios for wine grape production it is evident that the extra income gained by introducing drip irrigation systems will generate an average additional EUR 80 per year in taxes per hectare. If we extrapolate these extra taxes over a 15-year period, it is evident that the government will recover even more than the grants/subsidies provided for these types of investments (50% from the costs for investment in drip irrigation systems). In the case of table grape production, the extra income from introducing drip irrigation systems will generate an extra EUR 311 from taxes per hectare on annual basis. If we extrapolate these extra taxes over a 15-year period, the government will gain EUR 4,406 through taxes, which is four times more than the grants/subsidies provided for these types of investments, or two times more than the value of the drip system. Still, it is important to develop and strengthen the agriculture tax collecting system in order to collect these extra taxes.

- Local government should consider the option of supporting the allocation of vineyards at a higher altitude of 250 m and the construction of water-collecting systems. Based on the results of scenarios for wine grape production, investment in furrow irrigation and relocation to higher altitudes will generate an average of EUR 20 in taxes per hectare on an annual basis. Bearing in mind that these taxes will be paid at the latest in the next 15 years, these types of investment for this period will generate an additional EUR 300 per hectare in the budget. In the case of table grape production, investment in furrow irrigation and relocation to higher altitudes will generate an average additional EUR 300 in taxes per hectare on an annual basis. Bearing in mind that these taxes will be paid at the latest in the next 15 years, these types of investment for this period will generate EUR 4,500 per hectare. Local government can support this process through land planning, cadastre, land parcelization and construction. Additionally, the construction of water-collecting systems should be a priority, given that irrigation as an adaptation measure generates high financial results. Even though investments in land construction and water-collecting systems are very expensive, it is expected that comprehensive large-scale investment will reduce the investment costs per unit (hectare land or metric cubic dam). With this approach, the investment value for land construction and construction of water-collecting systems will be much lower compared to the indicative values used in this analysis. It is worth pointing out that these types of investments will last and gain benefit for the next 100 years, much longer than the 15 years used in this analysis. Still, it is highly recommended that experts are involved in the whole process, especially in preventing and monitoring of the investments impact on land erosion, biodiversity and appropriate irrigation.
- Besides providing direct payments support, it is necessary to design and implement programmes for raising public awareness and promoting the positive results and benefits of the adaptation measures.
- Close inter-sectoral and institutional cooperation is necessary to ensure successful implementation of the scenarios and to minimize the negative impacts of climate change on agricultural production.

Annex 1. METHODOLOGY AND ASSESSMENT NORMATIVE

Hypothesis 1. Water-collecting systems (dams/reservoirs) and adaptation measures exist

This hypothesis assumes that farmers already have irrigation skims, UV nets and access to water. Extra costs and income will be generated only from additional costs, extra irrigation water used and increased yield.

Main assumptions and indicators used for cost-benefit analyses in Hypothesis 1

	Irrigation		Altitude		UV net	
Furrow 0 m / 0°C	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2°C	- 5°C
SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3

Hypothesis: Extra costs for irrigation (I) will be incurred as a result of extra irrigation water (IW) used. Water price (WP) will be constant over the years and will not vary as a result of climate change and increased demand for water.

I = IW (m^3/ha) x PW (EUR/m^3)
PW (drip) = 1.64 MKD/m^3 or 0.27 EUR/m^3
PW (furrow) = 4.61 MKD/m^3 or 0.075 EUR/m^3
Hypothesis: Extra production costs will be incurred as a result of higher costs for transport and fuel at higher altitude (T)

T (+250 m) = 200 EUR/year
T (+500 m) = 400 EUR/year
Hypothesis: Extra costs will be generated as a result of extra labour needed for furrow construction for irrigation (L)

L = 450 EUR/year
Total extra costs (TC) are the sum of all extra costs arising from measures in the proposed scenario

TC = I + T + L
Hypothesis: Yield difference income (YDI): extra revenues generated as a result of the yield (Y) difference in comparison with the baseline scenario. The selling price (SP) of yield is constant and will not rise as a result of the effects of climate change on production, decreased yield and food shortage.

YDI = [Y (SC n) - Y(SC 0)] x PY (EUR/kg)
SP (table grape) = 25 MKD/kg or 0.41 EUR/kg
SP (wine grape) = 15 MKD/kg or 0.24 EUR/kg

Hypothesis: Increased quality income (IQI): extra revenues calculated based on the increased price of the yield as a result of yield increased quality (YIQ) and reduced sunburn spots

IQI = YIQ x SP after - Y (SC n) x SP before
YIQ = Y (SC n) x 4%
SP (before) = 15 MKD/kg or 0.24 EUR/kg
SP (after) = 27.5 MKD/kg or 0.45 EUR/kg
Extra income (EI) is the sum of all extra income as a result of the proposed measures

EI = YDI + IQI
Extra gross margin (EGM) is the difference between the extra revenue and extra costs

EGM = EI - TC
The profit (P) will be calculated after the deduction of the profit tax (PT)

P = EGM – EGM * PT
PT = 10% (if EGM is positive)
PT = 1.5% (if EGM is negative)

Hypothesis 2. Water-collection systems (dams/reservoirs) exist but investment is needed in adaptation measures

This hypothesis assumes that farmers have access to water, but need to invest in irrigation skims, UV nets and and land parcels at high altitudes.

Besides the costs involved in Hypothesis 1, additional costs will be incurred by annual depreciation and the maintenance of adaptation measure investments.

Main assumptions and indicators for the cost-benefit analysis of scenarios including investment in irrigation systems, UV nets and land construction (per year per hectare) used in Hypothesis 2

	Irrigation		Altitude		UV net	
Furrow 0 m /0°C	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2°C	- 5°C
SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3

Hypothesis: Present investment value of the different adaptation measure investments (AMI) per 1 ha

Drip Irrigation = 2,200 EUR/ha
UV net = 12,000 EUR/ha
Land construction (+250 m) = 1,500 EUR/ha
Land construction (+500 m) = 2,500 EUR/ha
Economical period of usage (EP) of the different adaptation measure investments

Drip Irrigation = 15 years
UV net = 10 years
Land construction = 15 years
Adaptation measure investments depreciation (D)

D = AMI (EUR) : EP (years)
Hypothesis: Costs for annual maintenance of the adaptation measure investments (M)

Drip Irrigation = 20 EUR/ha
UV net = 40 EUR/ha
Different adaptation measure investments costs per year (AMC)
AMC = D + M

Profit before taxation (PbT) will be calculated after investment costs are deducted from the Extra Gross Margin in Hypothesis 1

PbT = EGM - AMC
The profit (P) will be calculated after the deduction of the profit tax (PT)

P = PbT – PbT * PT
PT = 10% (if EGM is positive)
PT = 1.5% (if EGM is negative)

Hypothesis 3. No water-collecting systems (dams/reservoirs) or irrigation systems exist and must be invested in

The hypothesis presumes that farmers do not have access to water and must invest in the construction of water-collecting and irrigation systems.

Besides the costs in the Hypothesis 2, additional costs will be incurred with the annual depreciation of the water collecting system.[12]

Main assumption and indicators for the cost-benefit analysis of scenarios, including irrigation and water-collecting system investments per year per hectare used in Hypothesis 3

	Irrigation		Altitude		UV net	
Furrow 0 m / 0°C	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2°C	- 5°C
SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3

Hypothesis: Dam present investment value (DI) of the dam is product of the dam capacity (DC) and unit price (UP)

DI = DC (m^3) x UP (EUR/m^3)

UP = 1.06 EUR/m^3
Economical period of usage (EP)

Dam = 100 years
Dam Depreciation (DD) is calculated by dividing the investment value of dam by the economical period

DD = DI (EUR) : EP (years)
Hypothesis: dam depreciation will be added to the investment costs of the adaptation measure in Hypothesis 2

AMC = D + I + DD
Profit before taxation (PbT) will be calculated after investment costs are deducted from the Extra Gross Margin in Hypothesis 1

PbT = EGM - AMC
The profit (P) will be calculated after the deduction of the profit tax (PT)

P = PbT – PbT * PT
PT = 10% (if EGM is positive)
PT = 1.5% (if EGM is negative)

[12] The dam capacity is based on the scenario irrigation volume.

Assessment normative

1. Combination of official and expert observation of the water price

http://vodostopanstvotikves.com/cenovnik
http://www.alfa.mk/News.aspx?id=56430#.UcggGE38L4Y
http://www.vecer.com.mk/%5C?ItemID=B80181FF0A468C4883747D033881181D
http://www.idividi.com.mk/vesti/makedonija/377752/
http://www.novamakedonija.com.mk/NewsDetal.asp?vest=121911927384&id=10&setIzdanie=22459
http://www.tera.mk/aktuel/voda-od-strezhevo-za-zemjodelcite-od-novaci
http://vodostopanstvotikves.com/cenovnik

2. Combination of data from the official Agricultural Market Information System of the Ministry of Agriculture, Forestry and Water Economy, and expert observation of the selling prices for crops (http://www.zpis.gov.mk/index.php?lang=en)

SP (table grape) = 25 MKD/kg or 0.41 EUR/kg

SP (wine grape) = 15 MKD/kg or 0.24 EUR/kg

3. Combination of information from demonstration trials undertake by USAID/Rural Development Network of the Republic of Macedonia "Adaptation to Climate Change in Agriculture" and expert observation for the irrigation system and UV net investment, economic period and maintenance costs.

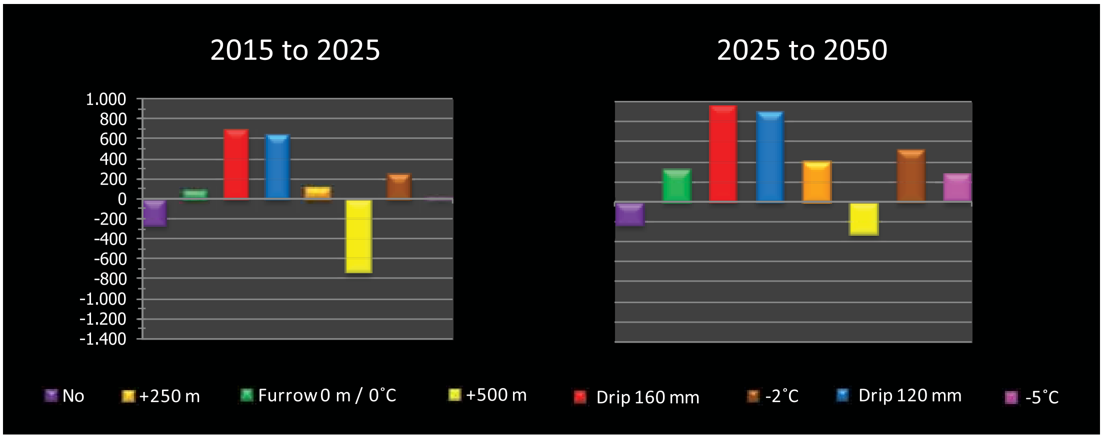
Drip Irrigation
Investment value = 2,200 EUR/ha
Maintains = 20 EUR/ha
Economic period = 15 years

UV net
Investment value = 12,000 EUR/ha
Maintains = 40 EUR/ha
Economic period = 10 years
Sunburn spots reduction = 4% of the yield
Furrow = 450 EUR/ha (estimated based on the labour needed to construct)
Water-collecting system (dam/reservoir)
Investment value = 1.06 EUR/m^3 (http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/book4water_from_small_damspdf.pdf)
Economic period = 100 years (based on estimation)

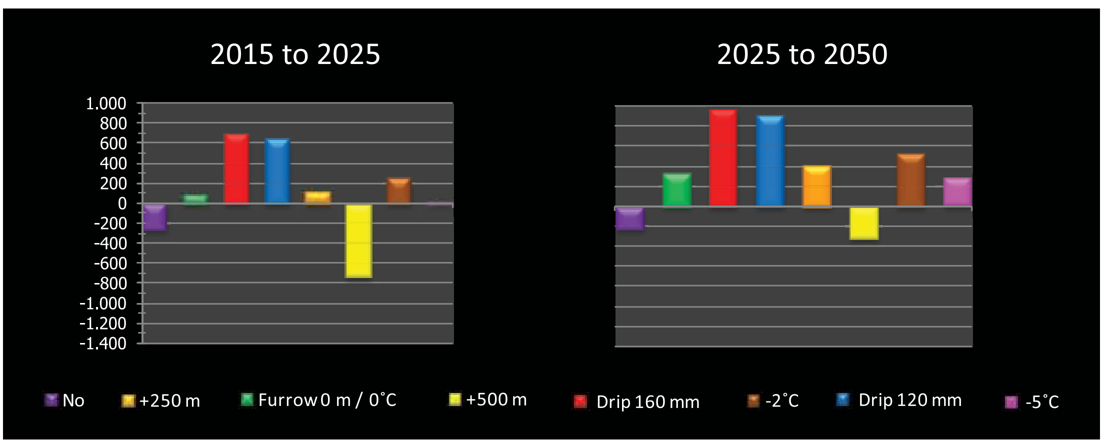
Annex 2. SUMMARY RESULTS

Results of cost-benefit analysis for wine grape production

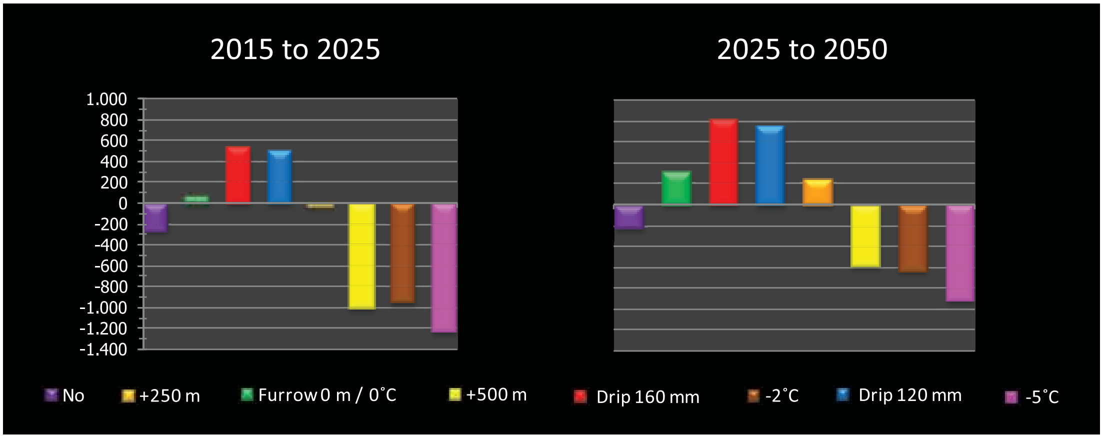
Hypothesis 1



Hypothesis 2

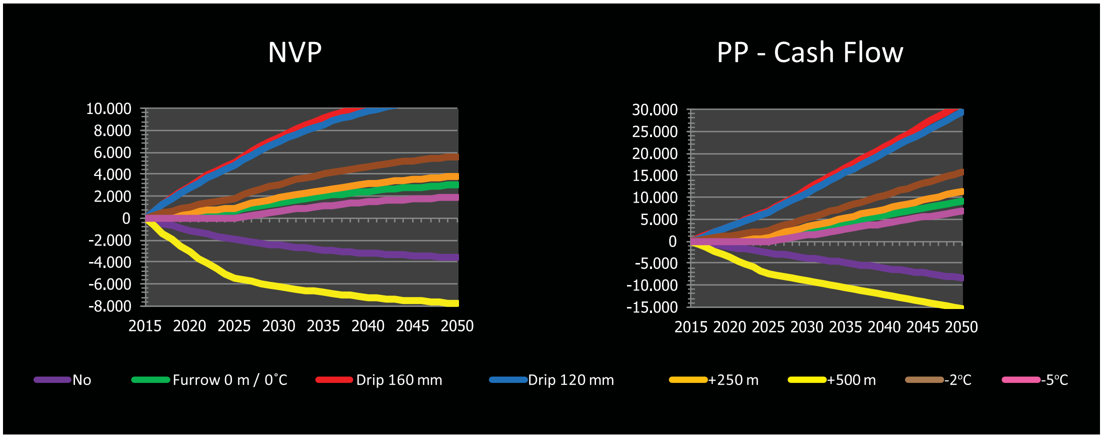


Hypothesis 3

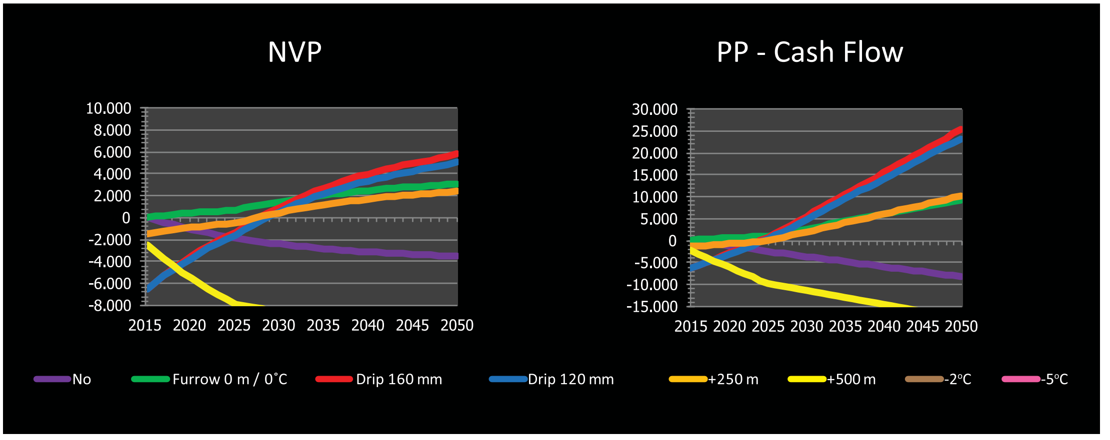


Wine Grape Economic feasibility

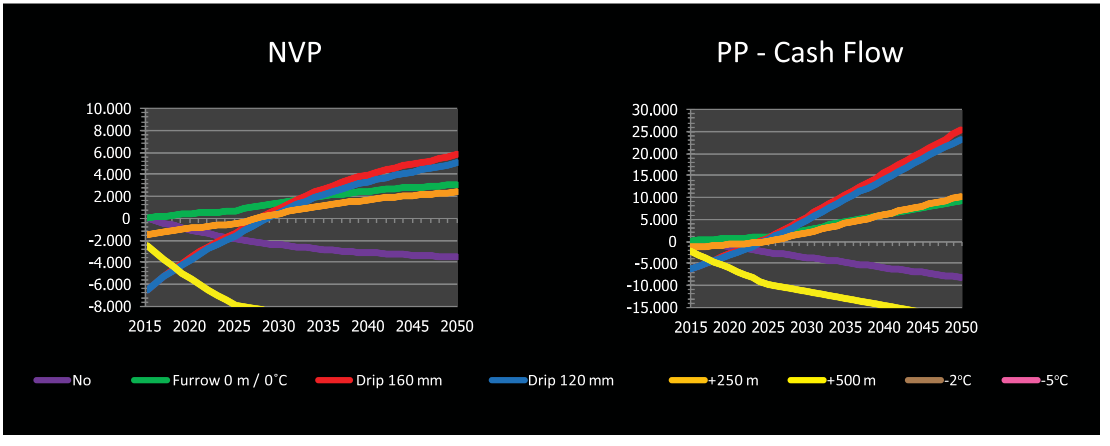
Hypothesis 1



Hypothesis 2

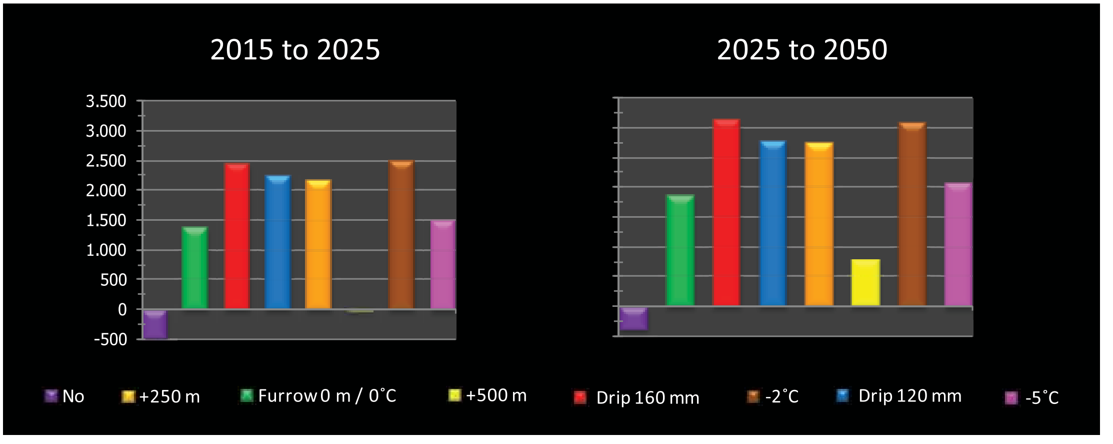


Hypothesis 3

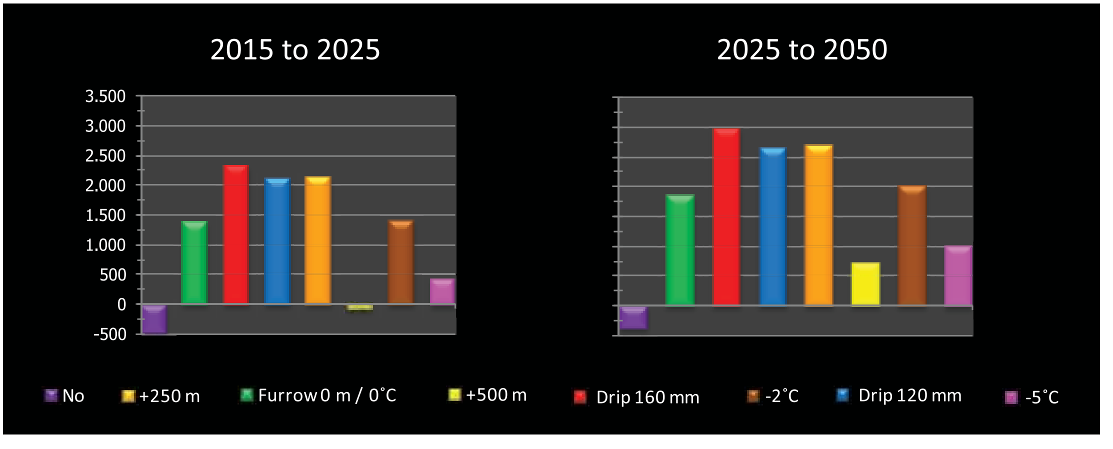


Results of cost-benefit analysis for table grape production

Hypothesis 1



Hypothesis 2



Hypothesis 3

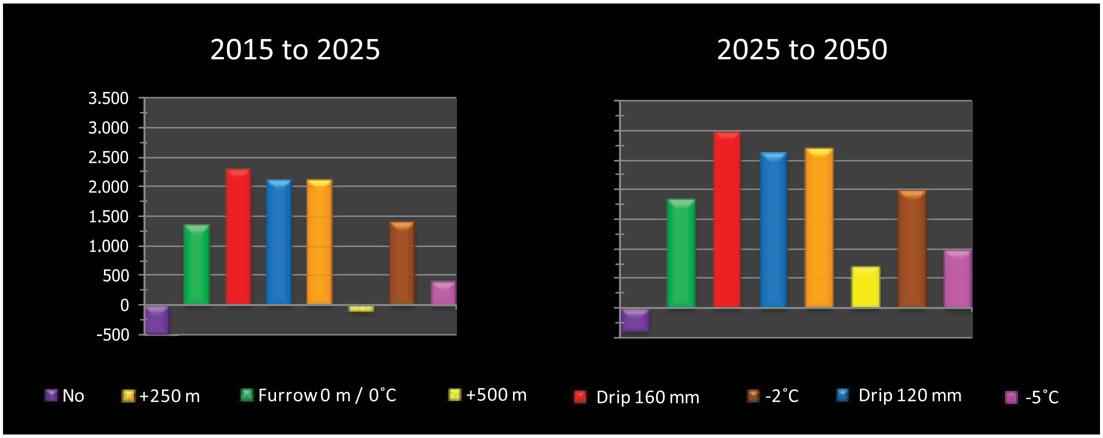
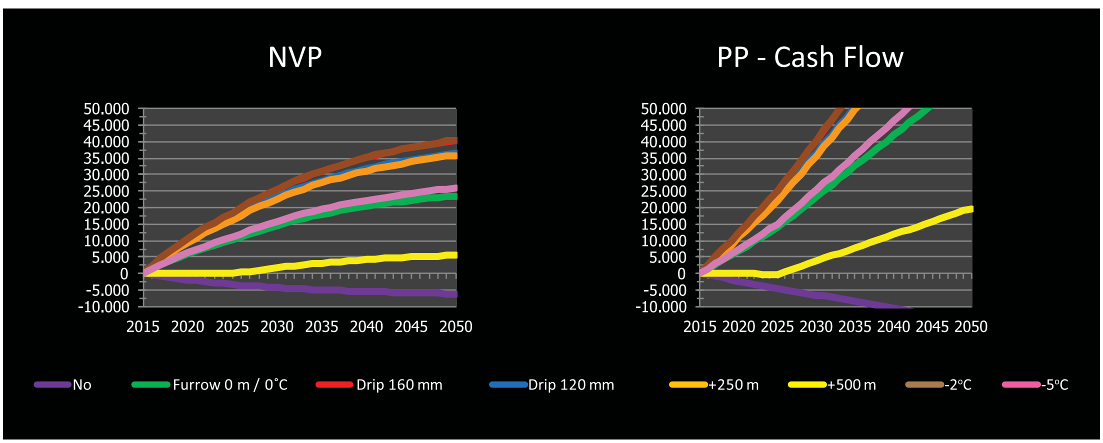
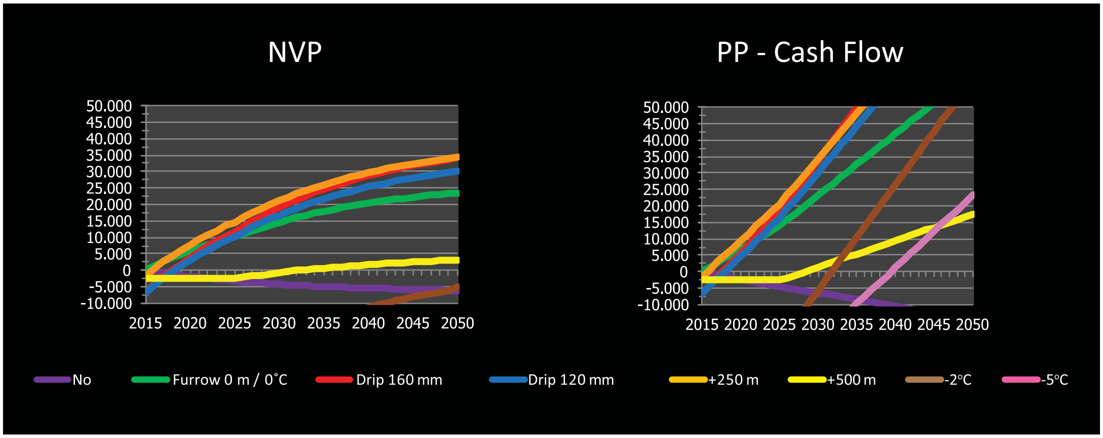


Table Grape Economic feasibility

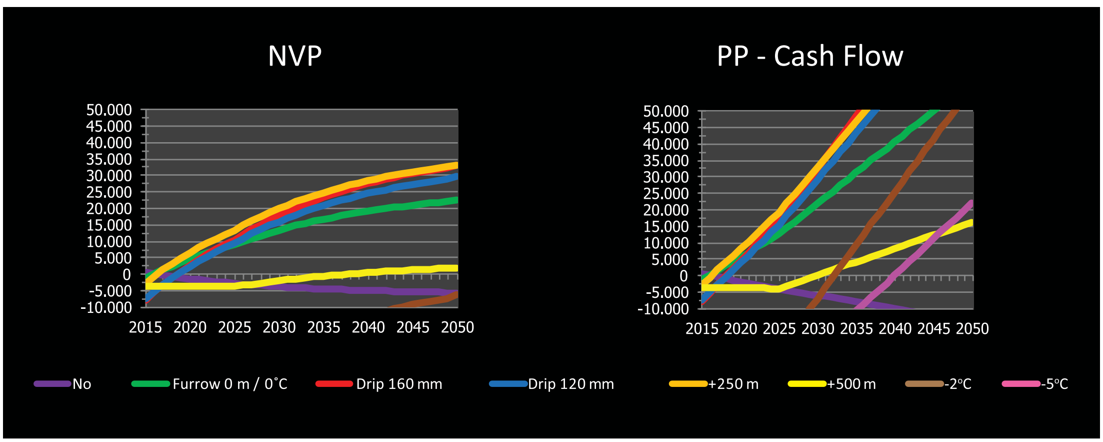
Hypothesis 1



Hypothesis 2

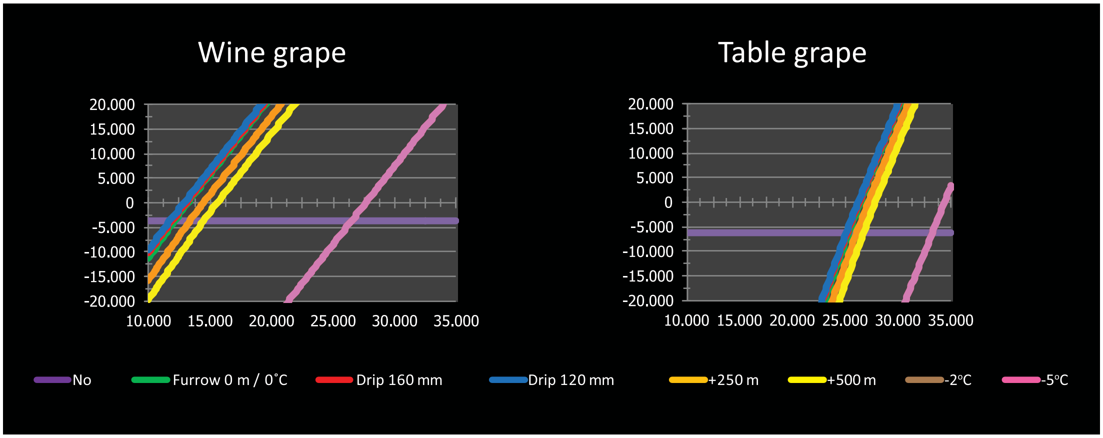


Hypothesis 3

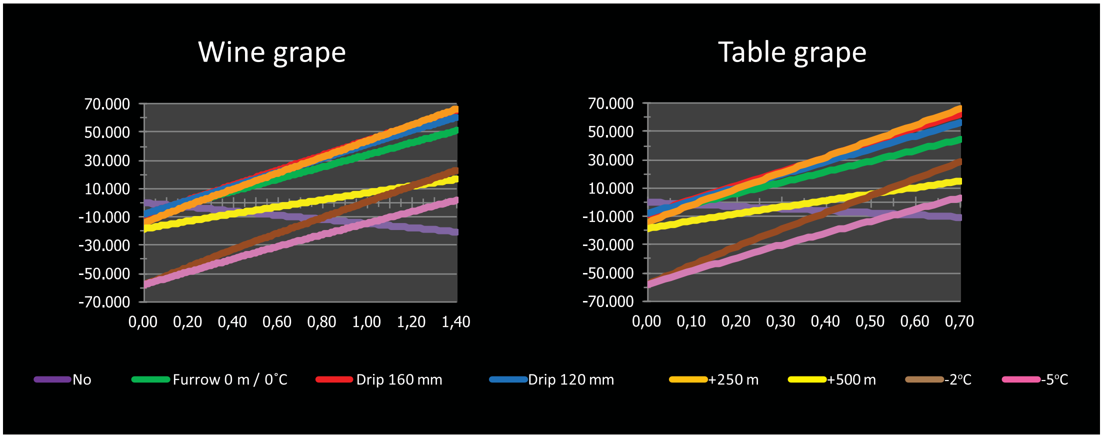


Annex 3. BREAK-EVEN FIGURES

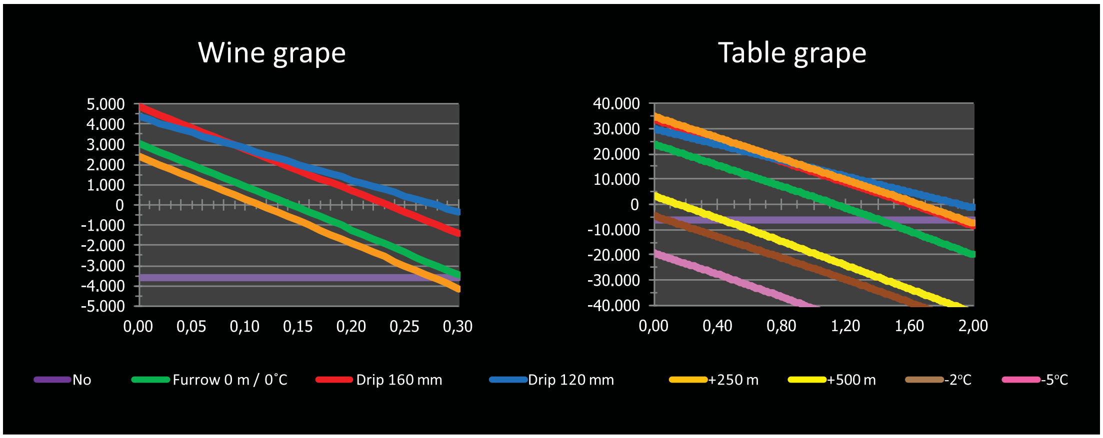
Scenario NPV Break-even in line with the yield (EUR-kg)



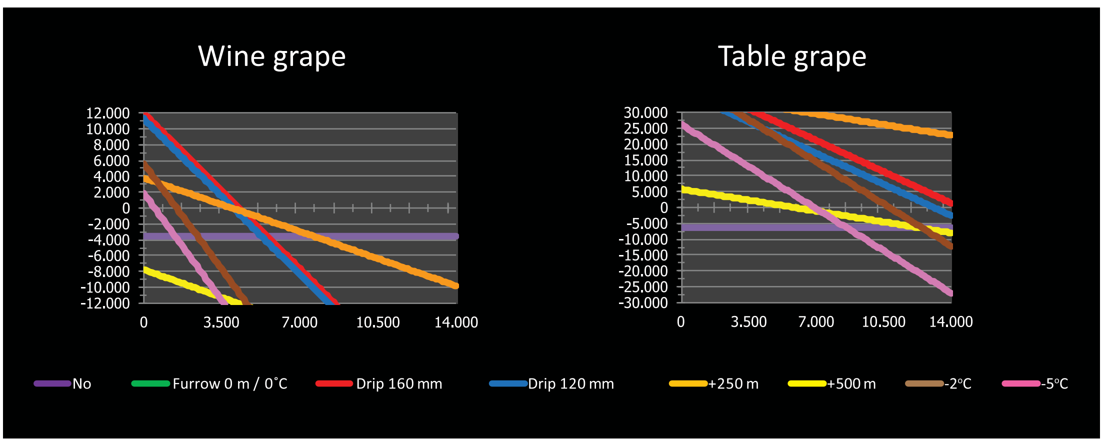
Scenario NPV Break-even in line with the grape selling price (EUR)



Scenario NPV Break-even in line with the price of water (EUR)



Scenario NPV Break-even in line with the size of investment (EUR)



Annex 4. ECONOMIC FEASIBILITY CALCULATIONS

Hypothesis 1. NPV calculation for wine grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0ºC	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		0	0	0	0	0	0	0
1	-248	84	653	617	117	-700	234	-2
2	-234	80	616	582	110	-660	220	-2
3	-221	75	581	549	104	-623	208	-2
4	-208	71	548	518	98	-588	196	-2
5	-197	67	517	489	93	-555	185	-2
6	-186	63	488	461	87	-523	175	-2
7	-175	60	460	435	82	-494	165	-2
8	-165	56	434	410	78	-466	155	-2
9	-156	53	410	387	73	-439	147	-2
10	-147	50	386	365	69	-414	138	-1
11	-122	174	513	479	213	-169	281	145
12	-115	164	484	452	201	-159	265	136
13	-108	155	457	426	189	-150	250	129
14	-102	146	431	402	179	-142	236	121
15	-96	138	407	379	169	-134	222	114
16	-91	130	384	358	159	-126	210	108
17	-86	123	362	338	150	-119	198	102
18	-81	116	341	319	142	-112	187	96
19	-76	109	322	301	134	-106	176	91
20	-72	103	304	284	126	-100	166	86
21	-68	97	287	267	119	-94	157	81
22	-64	92	270	252	112	-89	148	76
23	-60	87	255	238	106	-84	140	72
24	-57	82	241	225	100	-79	132	68
25	-54	77	227	212	94	-75	124	64
26	-51	73	214	200	89	-70	117	60
27	-48	69	202	189	84	-67	111	57
28	-45	65	191	178	79	-63	104	54
29	-43	61	180	168	75	-59	98	51
30	-40	58	170	158	70	-56	93	48
31	-38	54	160	149	66	-53	88	45
32	-36	51	151	141	63	-50	83	43
33	-34	48	142	133	59	-47	78	40
34	-32	46	134	125	56	-44	73	38
35	-30	43	127	118	53	-42	69	36
NPV	-3.584	3.018	12.049	11.305	3.796	-7.751	5.627	1.939

Hypothesis 1. PP and Cash flow calculation for wine grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0ºC	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		0	0	0	0	0	0	0
1	-263	90	692	654	124	-742	248	-3
2	-526	179	1.384	1.308	248	-1.484	495	-5
3	-789	269	2.076	1.962	372	-2.226	743	-8
4	-1.053	358	2.768	2.616	496	-2.968	991	-10
5	-1.316	448	3.461	3.270	620	-3.711	1.239	-13
6	-1.579	537	4.153	3.924	744	-4.453	1.486	-16
7	-1.842	627	4.845	4.578	868	-5.195	1.734	-18
8	-2.105	716	5.537	5.232	992	-5.937	1.982	-21
9	-2.368	806	6.229	5.886	1.116	-6.679	2.229	-23
10	-2.631	895	6.921	6.540	1.240	-7.421	2.477	-26
11	-2.862	1.226	7.895	7.450	1.644	-7.742	3.010	248
12	-3.093	1.556	8.870	8.359	2.048	-8.062	3.543	523
13	-3.324	1.887	9.844	9.268	2.452	-8.383	4.076	797
14	-3.554	2.217	10.818	10.178	2.856	-8.704	4.609	1.071
15	-3.785	2.547	11.793	11.087	3.260	-9.025	5.142	1.346
16	-4.016	2.878	12.767	11.997	3.664	-9.345	5.675	1.620
17	-4.246	3.208	13.741	12.906	4.068	-9.666	6.208	1.894
18	-4.477	3.539	14.716	13.815	4.472	-9.987	6.740	2.169
19	-4.708	3.869	15.690	14.725	4.876	-10.307	7.273	2.443
20	-4.939	4.200	16.664	15.634	5.280	-10.628	7.806	2.717
21	-5.169	4.530	17.638	16.543	5.684	-10.949	8.339	2.992
22	-5.400	4.860	18.613	17.453	6.088	-11.269	8.872	3.266
23	-5.631	5.191	19.587	18.362	6.492	-11.590	9.405	3.540
24	-5.861	5.521	20.561	19.272	6.896	-11.911	9.938	3.815
25	-6.092	5.852	21.536	20.181	7.300	-12.231	10.471	4.089
26	-6.323	6.182	22.510	21.090	7.704	-12.552	11.004	4.363
27	-6.554	6.513	23.484	22.000	8.108	-12.873	11.537	4.638
28	-6.784	6.843	24.458	22.909	8.512	-13.194	12.070	4.912
29	-7.015	7.173	25.433	23.818	8.916	-13.514	12.603	5.186
30	-7.246	7.504	26.407	24.728	9.320	-13.835	13.136	5.461
31	-7.476	7.834	27.381	25.637	9.724	-14.156	13.669	5.735
32	-7.707	8.165	28.356	26.546	10.128	-14.476	14.201	6.009
33	-7.938	8.495	29.330	27.456	10.532	-14.797	14.734	6.284
34	-8.169	8.826	30.304	28.365	10.936	-15.118	15.267	6.558
35	-8.399	9.156	31.279	29.275	11.340	-15.438	15.800	6.832

Hypothesis 2. NPV calculation for wine grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0ºC	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		0	-6.600	-6.600	-1.500	-2.500	-48.000	-48.000
1	-248	84	667	631	121	-701	247	-19
2	-234	80	629	595	114	-661	233	-18
3	-221	75	593	561	108	-624	219	-17
4	-208	71	560	530	102	-589	207	-16
5	-197	67	528	500	96	-555	195	-15
6	-186	63	498	471	90	-524	184	-15
7	-175	60	470	445	85	-494	174	-14
8	-165	56	443	420	80	-466	164	-13
9	-156	53	418	396	76	-440	155	-12
10	-147	50	395	373	72	-415	146	-12
11	-122	174	521	487	215	-170	307	154
12	-115	164	491	459	203	-160	290	145
13	-108	155	464	433	191	-151	273	137
14	-102	146	437	409	181	-142	258	129
15	-96	138	413	386	170	-134	243	122
16	-91	130	389	364	161	-127	230	115
17	-86	123	367	343	152	-119	217	108
18	-81	116	346	324	143	-113	204	102
19	-76	109	327	305	135	-106	193	96
20	-72	103	308	288	127	-100	182	91
21	-68	97	291	272	120	-95	171	86
22	-64	92	274	256	113	-89	162	81
23	-60	87	259	242	107	-84	153	76
24	-57	82	244	228	101	-79	144	72
25	-54	77	230	215	95	-75	136	68
26	-51	73	217	203	90	-71	128	64
27	-48	69	205	192	85	-67	121	60
28	-45	65	193	181	80	-63	114	57
29	-43	61	183	171	75	-59	108	54
30	-40	58	172	161	71	-56	102	51
31	-38	54	162	152	67	-53	96	48
32	-36	51	153	143	63	-50	90	45
33	-34	48	145	135	60	-47	85	43
34	-32	46	136	127	56	-44	80	40
35	-30	43	319	311	53	-42	856	819
NPV	-3.584	3.018	5.852	5.108	2.358	-10.267	-41.134	-45.291

Hypothesis 2. PP and Cash flow calculation for wine grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0ºC	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		0	-6.600	-6.600	-1.500	-2.500	-48.000	-48.000
1	-263	90	-5.893	-5.931	-1.372	-3.243	-47.739	-48.021
2	-526	179	-5.186	-5.263	-1.244	-3.986	-47.477	-48.041
3	-789	269	-4.480	-4.594	-1.115	-4.730	-47.216	-48.062
4	-1.053	358	-3.773	-3.925	-987	-5.473	-46.955	-48.082
5	-1.316	448	-3.066	-3.256	-859	-6.216	-46.693	-48.103
6	-1.579	537	-2.359	-2.588	-731	-6.959	-46.432	-48.124
7	-1.842	627	-1.653	-1.919	-602	-7.702	-46.170	-48.144
8	-2.105	716	-946	-1.250	-474	-8.445	-45.909	-48.165
9	-2.368	806	-239	-582	-346	-9.189	-45.648	-48.185
10	-2.631	895	468	87	-218	-9.932	-45.386	-48.206
11	-2.862	1.226	1.457	1.011	191	-10.254	-44.803	-47.915
12	-3.093	1.556	2.446	1.935	599	-10.575	-44.220	-47.623
13	-3.324	1.887	3.435	2.859	1.007	-10.897	-43.637	-47.332
14	-3.554	2.217	4.424	3.783	1.416	-11.219	-43.054	-47.040
15	-3.785	2.547	5.413	4.707	1.824	-11.541	-42.471	-46.749
16	-4.016	2.878	6.402	5.631	2.232	-11.862	-41.888	-46.458
17	-4.246	3.208	7.391	6.555	2.640	-12.184	-41.305	-46.166
18	-4.477	3.539	8.380	7.479	3.049	-12.506	-40.722	-45.875
19	-4.708	3.869	9.368	8.403	3.457	-12.828	-40.139	-45.583
20	-4.939	4.200	10.357	9.327	3.865	-13.149	-39.556	-45.292
21	-5.169	4.530	11.346	10.251	4.274	-13.471	-38.973	-45.001
22	-5.400	4.860	12.335	11.175	4.682	-13.793	-38.390	-44.709
23	-5.631	5.191	13.324	12.100	5.090	-14.115	-37.807	-44.418
24	-5.861	5.521	14.313	13.024	5.498	-14.436	-37.224	-44.126
25	-6.092	5.852	15.302	13.948	5.907	-14.758	-36.641	-43.835
26	-6.323	6.182	16.291	14.872	6.315	-15.080	-36.058	-43.544
27	-6.554	6.513	17.280	15.796	6.723	-15.402	-35.475	-43.252
28	-6.784	6.843	18.269	16.720	7.132	-15.724	-34.892	-42.961
29	-7.015	7.173	19.258	17.644	7.540	-16.045	-34.309	-42.670
30	-7.246	7.504	20.247	18.568	7.948	-16.367	-33.726	-42.378
31	-7.476	7.834	21.236	19.492	8.356	-16.689	-33.143	-42.087
32	-7.707	8.165	22.225	20.416	8.765	-17.011	-32.560	-41.795
33	-7.938	8.495	23.214	21.340	9.173	-17.332	-31.977	-41.504
34	-8.169	8.826	24.203	22.264	9.581	-17.654	-31.394	-41.213
35	-8.399	9.156	25.192	23.188	9.990	-17.976	-30.811	-40.921

Hypothesis 2. IRR calculation for wine grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		0	-6.600	-6.600	-1.500	-2.500	-48.000	-48.000
1	-263	90	707	669	128	-743	261	-21
2	-263	90	707	669	128	-743	261	-21
3	-263	90	707	669	128	-743	261	-21
4	-263	90	707	669	128	-743	261	-21
5	-263	90	707	669	128	-743	261	-21
6	-263	90	707	669	128	-743	261	-21
7	-263	90	707	669	128	-743	261	-21
8	-263	90	707	669	128	-743	261	-21
9	-263	90	707	669	128	-743	261	-21
10	-263	90	707	669	128	-743	261	-21
11	-231	330	989	924	408	-322	583	291
12	-231	330	989	924	408	-322	583	291
13	-231	330	989	924	408	-322	583	291
14	-231	330	989	924	408	-322	583	291
15	-231	330	989	924	408	-322	583	291
16	-231	330	989	924	408	-322	583	291
17	-231	330	989	924	408	-322	583	291
18	-231	330	989	924	408	-322	583	291
19	-231	330	989	924	408	-322	583	291
20	-231	330	989	924	408	-322	583	291
21	-231	330	989	924	408	-322	583	291
22	-231	330	989	924	408	-322	583	291
23	-231	330	989	924	408	-322	583	291
24	-231	330	989	924	408	-322	583	291
25	-231	330	989	924	408	-322	583	291
26	-231	330	989	924	408	-322	583	291
27	-231	330	989	924	408	-322	583	291
28	-231	330	989	924	408	-322	583	291
29	-231	330	989	924	408	-322	583	291
30	-231	330	989	924	408	-322	583	291
31	-231	330	989	924	408	-322	583	291
32	-231	330	989	924	408	-322	583	291
33	-231	330	989	924	408	-322	583	291
34	-231	330	989	924	408	-322	583	291
35	-231	330	2.456	2.391	408	-322	6.583	6.291
IRR			11,86%	11,19%	13,49%			

Hypothesis 3. NPV calculation for wine grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0ºC	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		-1.723	-8.323	-7.892	-3.223	-4.223	-49.723	-49.723
1	-248	86	668	632	123	-701	246	-20
2	-234	81	631	596	116	-662	232	-19
3	-221	77	595	563	109	-624	219	-18
4	-208	72	561	531	103	-589	207	-17
5	-197	68	529	501	97	-556	195	-16
6	-186	64	499	472	92	-524	184	-15
7	-175	61	471	446	86	-494	174	-14
8	-165	57	445	420	82	-466	164	-13
9	-156	54	419	397	77	-440	155	-12
10	-147	51	396	374	73	-415	146	-12
11	-122	175	522	487	216	-170	307	153
12	-115	165	492	460	204	-160	290	145
13	-108	156	464	434	192	-151	273	136
14	-102	147	438	409	181	-142	258	129
15	-96	139	413	386	171	-134	243	121
16	-91	131	390	364	161	-127	229	115
17	-86	123	368	344	152	-120	216	108
18	-81	116	347	324	144	-113	204	102
19	-76	110	327	306	136	-106	193	96
20	-72	104	309	289	128	-100	182	91
21	-68	98	291	272	121	-95	171	86
22	-64	92	275	257	114	-89	162	81
23	-60	87	259	242	107	-84	153	76
24	-57	82	245	229	101	-80	144	72
25	-54	77	231	216	96	-75	136	68
26	-51	73	218	203	90	-71	128	64
27	-48	69	205	192	85	-67	121	60
28	-45	65	194	181	80	-63	114	57
29	-43	61	183	171	76	-59	108	54
30	-40	58	172	161	71	-56	101	51
31	-38	55	163	152	67	-53	96	48
32	-36	51	154	143	64	-50	90	45
33	-34	49	145	135	60	-47	85	43
34	-32	46	137	128	57	-44	80	40
35	-30	189	465	420	199	104	1.002	964
NPV	-3.584	1.465	4.300	3.944	806	-11.848	-42.715	-46.872

Hypothesis 3. PP and Cash flow calculation for wine grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160 mm	Капење 120 mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		-1.723	-8.323	-7.892	-3.223	-4.223	-49.723	-49.723
1	-263	-1.632	-7.615	-7.222	-3.093	-4.967	-49.462	-49.744
2	-526	-1.541	-6.906	-6.552	-2.963	-5.710	-49.201	-49.765
3	-789	-1.449	-6.198	-5.882	-2.833	-6.453	-48.940	-49.786
4	-1.053	-1.358	-5.489	-5.212	-2.703	-7.197	-48.679	-49.806
5	-1.316	-1.267	-4.781	-4.542	-2.573	-7.940	-48.418	-49.827
6	-1.579	-1.176	-4.072	-3.872	-2.443	-8.684	-48.156	-49.848
7	-1.842	-1.084	-3.364	-3.202	-2.313	-9.427	-47.895	-49.869
8	-2.105	-993	-2.655	-2.532	-2.183	-10.171	-47.634	-49.890
9	-2.368	-902	-1.947	-1.862	-2.053	-10.914	-47.373	-49.911
10	-2.631	-811	-1.238	-1.192	-1.923	-11.657	-47.112	-49.932
11	-2.862	-478	-247	-267	-1.513	-11.979	-46.529	-49.640
12	-3.093	-146	743	658	-1.103	-12.302	-45.947	-49.349
13	-3.324	186	1.734	1.584	-693	-12.624	-45.364	-49.058
14	-3.554	518	2.725	2.509	-283	-12.946	-44.781	-48.767
15	-3.785	850	3.715	3.434	127	-13.268	-44.198	-48.476
16	-4.016	1.182	4.706	4.360	537	-13.590	-43.615	-48.185
17	-4.246	1.515	5.697	5.285	947	-13.912	-43.033	-47.894
18	-4.477	1.847	6.687	6.210	1.357	-14.234	-42.450	-47.603
19	-4.708	2.179	7.678	7.136	1.767	-14.556	-41.867	-47.311
20	-4.939	2.511	8.669	8.061	2.177	-14.878	-41.284	-47.020
21	-5.169	2.843	9.660	8.986	2.587	-15.200	-40.702	-46.729
22	-5.400	3.175	10.650	9.912	2.997	-15.522	-40.119	-46.438
23	-5.631	3.507	11.641	10.837	3.407	-15.844	-39.536	-46.147
24	-5.861	3.840	12.632	11.762	3.817	-16.166	-38.953	-45.856
25	-6.092	4.172	13.622	12.688	4.227	-16.488	-38.371	-45.565
26	-6.323	4.504	14.613	13.613	4.637	-16.810	-37.788	-45.274
27	-6.554	4.836	15.604	14.538	5.047	-17.132	-37.205	-44.982
28	-6.784	5.168	16.594	15.464	5.457	-17.454	-36.622	-44.691
29	-7.015	5.500	17.585	16.389	5.867	-17.776	-36.040	-44.400
30	-7.246	5.833	18.576	17.314	6.277	-18.098	-35.457	-44.109
31	-7.476	6.165	19.566	18.240	6.687	-18.420	-34.874	-43.818
32	-7.707	6.497	20.557	19.165	7.097	-18.742	-34.291	-43.527
33	-7.938	6.829	21.548	20.090	7.507	-19.064	-33.708	-43.236
34	-8.169	7.161	22.538	21.016	7.917	-19.386	-33.126	-42.944
35	-8.399	7.493	23.529	21.941	8.327	-19.708	-32.543	-42.653

Hypothesis 3. IRR calculation for wine grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		-1.723	-8.323	-7.892	-3.223	-4.223	-49.723	-49.723
1	-263	91	709	670	130	-743	261	-21
2	-263	91	709	670	130	-743	261	-21
3	-263	91	709	670	130	-743	261	-21
4	-263	91	709	670	130	-743	261	-21
5	-263	91	709	670	130	-743	261	-21
6	-263	91	709	670	130	-743	261	-21
7	-263	91	709	670	130	-743	261	-21
8	-263	91	709	670	130	-743	261	-21
9	-263	91	709	670	130	-743	261	-21
10	-263	91	709	670	130	-743	261	-21
11	-231	332	991	925	410	-322	583	291
12	-231	332	991	925	410	-322	583	291
13	-231	332	991	925	410	-322	583	291
14	-231	332	991	925	410	-322	583	291
15	-231	332	991	925	410	-322	583	291
16	-231	332	991	925	410	-322	583	291
17	-231	332	991	925	410	-322	583	291
18	-231	332	991	925	410	-322	583	291
19	-231	332	991	925	410	-322	583	291
20	-231	332	991	925	410	-322	583	291
21	-231	332	991	925	410	-322	583	291
22	-231	332	991	925	410	-322	583	291
23	-231	332	991	925	410	-322	583	291
24	-231	332	991	925	410	-322	583	291
25	-231	332	991	925	410	-322	583	291
26	-231	332	991	925	410	-322	583	291
27	-231	332	991	925	410	-322	583	291
28	-231	332	991	925	410	-322	583	291
29	-231	332	991	925	410	-322	583	291
30	-231	332	991	925	410	-322	583	291
31	-231	332	991	925	410	-322	583	291
32	-231	332	991	925	410	-322	583	291
33	-231	332	991	925	410	-322	583	291
34	-231	332	991	925	410	-322	583	291
35	-231	1.452	3.577	3.232	1.530	798	7.703	7.411
IRR		10,17%	9,51%	9,42%	7,45%			

Hypothesis 1. NPV calculation for table grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0ºC	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		0	0	0	0	0	0	0
1	-427	1.309	2.326	2.136	2.068	-13	2.361	1.409
2	-402	1.235	2.194	2.015	1.951	-13	2.228	1.330
3	-380	1.165	2.070	1.901	1.841	-12	2.102	1.254
4	-358	1.099	1.953	1.793	1.737	-11	1.983	1.183
5	-338	1.037	1.842	1.692	1.638	-11	1.870	1.116
6	-319	978	1.738	1.596	1.546	-10	1.765	1.053
7	-301	923	1.640	1.506	1.458	-9	1.665	994
8	-284	870	1.547	1.421	1.376	-9	1.570	937
9	-268	821	1.459	1.340	1.298	-8	1.482	884
10	-253	775	1.377	1.264	1.224	-8	1.398	834
11	-206	985	1.651	1.467	1.453	420	1.631	1.097
12	-194	929	1.557	1.384	1.371	396	1.539	1.035
13	-183	876	1.469	1.306	1.293	374	1.452	976
14	-173	827	1.386	1.232	1.220	353	1.369	921
15	-163	780	1.308	1.162	1.151	333	1.292	869
16	-154	736	1.234	1.096	1.086	314	1.219	820
17	-145	694	1.164	1.034	1.024	296	1.150	773
18	-137	655	1.098	976	966	279	1.085	729
19	-129	618	1.036	920	912	264	1.023	688
20	-122	583	977	868	860	249	965	649
21	-115	550	922	819	811	235	911	612
22	-109	519	870	773	765	221	859	578
23	-102	489	820	729	722	209	811	545
24	-97	462	774	688	681	197	765	514
25	-91	436	730	649	643	186	721	485
26	-86	411	689	612	606	175	681	458
27	-81	388	650	577	572	165	642	432
28	-76	366	613	545	540	156	606	407
29	-72	345	578	514	509	147	571	384
30	-68	325	546	485	480	139	539	362
31	-64	307	515	457	453	131	509	342
32	-61	290	486	432	427	124	480	323
33	-57	273	458	407	403	117	453	304
34	-54	258	432	384	380	110	427	287
35	-51	243	408	362	359	104	403	271
NPV	-6.120	23.555	40.515	36.544	35.823	5.587	40.524	25.858

Hypothesis 1. PP and Cash flow calculation for table grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		0	0	0	0	0	0	0
1	-452	1.387	2.465	2.264	2.192	-14	2.503	1.494
2	-904	2.775	4.931	4.528	4.385	-28	5.006	2.988
3	-1.357	4.162	7.396	6.793	6.577	-43	7.509	4.482
4	-1.809	5.549	9.862	9.057	8.770	-57	10.013	5.976
5	-2.261	6.937	12.327	11.321	10.962	-71	12.516	7.470
6	-2.713	8.324	14.793	13.585	13.155	-85	15.019	8.964
7	-3.166	9.711	17.258	15.849	15.347	-100	17.522	10.458
8	-3.618	11.099	19.724	18.113	17.540	-114	20.025	11.952
9	-4.070	12.486	22.189	20.378	19.732	-128	22.528	13.446
10	-4.522	13.874	24.655	22.642	21.925	-142	25.031	14.940
11	-4.914	15.743	27.788	25.427	24.683	655	28.127	17.022
12	-5.305	17.612	30.922	28.212	27.441	1.452	31.224	19.104
13	-5.696	19.482	34.056	30.996	30.199	2.250	34.320	21.186
14	-6.087	21.351	37.190	33.781	32.956	3.047	37.416	23.268
15	-6.478	23.221	40.323	36.566	35.714	3.844	40.512	25.350
16	-6.869	25.090	43.457	39.351	38.472	4.641	43.608	27.432
17	-7.260	26.960	46.591	42.136	41.230	5.439	46.704	29.514
18	-7.651	28.829	49.725	44.921	43.988	6.236	49.800	31.596
19	-8.042	30.699	52.858	47.706	46.746	7.033	52.896	33.678
20	-8.433	32.568	55.992	50.491	49.504	7.831	55.992	35.760
21	-8.824	34.438	59.126	53.276	52.262	8.628	59.088	37.842
22	-9.215	36.307	62.260	56.060	55.020	9.425	62.185	39.924
23	-9.606	38.176	65.393	58.845	57.777	10.223	65.281	42.006
24	-9.997	40.046	68.527	61.630	60.535	11.020	68.377	44.088
25	-10.388	41.915	71.661	64.415	63.293	11.817	71.473	46.170
26	-10.779	43.785	74.795	67.200	66.051	12.615	74.569	48.252
27	-11.170	45.654	77.928	69.985	68.809	13.412	77.665	50.334
28	-11.561	47.524	81.062	72.770	71.567	14.209	80.761	52.416
29	-11.952	49.393	84.196	75.555	74.325	15.006	83.857	54.498
30	-12.343	51.263	87.330	78.339	77.083	15.804	86.953	56.580
31	-12.734	53.132	90.463	81.124	79.840	16.601	90.049	58.662
32	-13.125	55.002	93.597	83.909	82.598	17.398	93.145	60.744
33	-13.516	56.871	96.731	86.694	85.356	18.196	96.242	62.825
34	-13.907	58.740	99.865	89.479	88.114	18.993	99.338	64.907
35	-14.298	60.610	102.998	92.264	90.872	19.790	102.434	66.989

Hypothesis 2. NPV calculation for table grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		0	-6.600	-6.600	-1.500	-2.500	-48.000	-48.000
1	-427	1.309	2.340	2.150	2.072	-14	2.475	1.523
2	-402	1.235	2.207	2.028	1.955	-14	2.335	1.436
3	-380	1.165	2.082	1.913	1.844	-13	2.202	1.355
4	-358	1.099	1.964	1.805	1.740	-12	2.078	1.278
5	-338	1.037	1.853	1.703	1.642	-11	1.960	1.206
6	-319	978	1.748	1.606	1.549	-11	1.849	1.138
7	-301	923	1.649	1.516	1.461	-10	1.745	1.073
8	-284	870	1.556	1.430	1.378	-10	1.646	1.013
9	-268	821	1.468	1.349	1.300	-9	1.553	955
10	-253	775	1.385	1.272	1.227	-9	1.465	901
11	-206	985	1.659	1.475	1.455	424	1.694	1.160
12	-194	929	1.565	1.391	1.373	400	1.598	1.094
13	-183	876	1.476	1.313	1.295	377	1.508	1.032
14	-173	827	1.393	1.238	1.222	356	1.422	974
15	-163	780	1.314	1.168	1.153	336	1.342	919
16	-154	736	1.239	1.102	1.087	317	1.266	867
17	-145	694	1.169	1.040	1.026	299	1.194	818
18	-137	655	1.103	981	968	282	1.127	771
19	-129	618	1.041	925	913	266	1.063	728
20	-122	583	982	873	861	251	1.003	687
21	-115	550	926	824	813	237	946	648
22	-109	519	874	777	767	223	892	611
23	-102	489	824	733	723	211	842	576
24	-97	462	778	691	682	199	794	544
25	-91	436	734	652	644	187	749	513
26	-86	411	692	615	607	177	707	484
27	-81	388	653	581	573	167	667	457
28	-76	366	616	548	540	157	629	431
29	-72	345	581	517	510	148	594	406
30	-68	325	548	487	481	140	560	383
31	-64	307	517	460	454	132	528	362
32	-61	290	488	434	428	125	498	341
33	-57	273	460	409	404	118	470	322
34	-54	258	434	386	381	111	444	304
35	-51	243	600	555	359	105	1.199	1.067
NPV	-6.120	23.555	34.319	30.347	34.385	3.130	-4.956	-19.622

Hypothesis 2. PP and Cash flow calculation for table grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0ºC	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		0	-6.600	-6.600	-1.500	-2.500	-48.000	-48.000
1	-452	1.387	-4.120	-4.321	697	-2.515	-45.377	-46.386
2	-904	2.775	-1.640	-2.042	2.894	-2.531	-42.754	-44.772
3	-1.357	4.162	840	237	5.090	-2.546	-40.131	-43.158
4	-1.809	5.549	3.321	2.515	7.287	-2.561	-37.507	-41.544
5	-2.261	6.937	5.801	4.794	9.484	-2.577	-34.884	-39.930
6	-2.713	8.324	8.281	7.073	11.681	-2.592	-32.261	-38.316
7	-3.166	9.711	10.761	9.352	13.877	-2.607	-29.638	-36.702
8	-3.618	11.099	13.241	11.631	16.074	-2.622	-27.015	-35.088
9	-4.070	12.486	15.721	13.910	18.271	-2.638	-24.392	-33.474
10	-4.522	13.874	18.201	16.188	20.468	-2.653	-21.769	-31.860
11	-4.914	15.743	21.350	18.988	23.230	-1.849	-18.553	-29.658
12	-5.305	17.612	24.498	21.788	25.992	-1.044	-15.336	-27.456
13	-5.696	19.482	27.647	24.587	28.754	-240	-12.120	-25.254
14	-6.087	21.351	30.795	27.387	31.516	565	-8.904	-23.052
15	-6.478	23.221	33.943	30.186	34.279	1.369	-5.688	-20.850
16	-6.869	25.090	37.092	32.986	37.041	2.174	-2.472	-18.648
17	-7.260	26.960	40.240	35.785	39.803	2.978	744	-16.446
18	-7.651	28.829	43.389	38.585	42.565	3.783	3.960	-14.244
19	-8.042	30.699	46.537	41.384	45.327	4.587	7.176	-12.042
20	-8.433	32.568	49.685	44.184	48.089	5.391	10.392	-9.840
21	-8.824	34.438	52.834	46.984	50.852	6.196	13.608	-7.638
22	-9.215	36.307	55.982	49.783	53.614	7.000	16.825	-5.436
23	-9.606	38.176	59.131	52.583	56.376	7.805	20.041	-3.234
24	-9.997	40.046	62.279	55.382	59.138	8.609	23.257	-1.032
25	-10.388	41.915	65.427	58.182	61.900	9.414	26.473	1.170
26	-10.779	43.785	68.576	60.981	64.662	10.218	29.689	3.372
27	-11.170	45.654	71.724	63.781	67.425	11.023	32.905	5.574
28	-11.561	47.524	74.873	66.580	70.187	11.827	36.121	7.776
29	-11.952	49.393	78.021	69.380	72.949	12.631	39.337	9.978
30	-12.343	51.263	81.170	72.179	75.711	13.436	42.553	12.180
31	-12.734	53.132	84.318	74.979	78.473	14.240	45.769	14.382
32	-13.125	55.002	87.466	77.779	81.236	15.045	48.985	16.584
33	-13.516	56.871	90.615	80.578	83.998	15.849	52.202	18.785
34	-13.907	58.740	93.763	83.378	86.760	16.654	55.418	20.987
35	-14.298	60.610	96.912	86.177	89.522	17.458	58.634	23.189

Hypothesis 2. IRR calculation for table grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0ºC	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		0	-6.600	-6.600	-1.500	-2.500	-48.000	-48.000
1	-452	1.387	2.480	2.279	2.197	-15	2.623	1.614
2	-452	1.387	2.480	2.279	2.197	-15	2.623	1.614
3	-452	1.387	2.480	2.279	2.197	-15	2.623	1.614
4	-452	1.387	2.480	2.279	2.197	-15	2.623	1.614
5	-452	1.387	2.480	2.279	2.197	-15	2.623	1.614
6	-452	1.387	2.480	2.279	2.197	-15	2.623	1.614
7	-452	1.387	2.480	2.279	2.197	-15	2.623	1.614
8	-452	1.387	2.480	2.279	2.197	-15	2.623	1.614
9	-452	1.387	2.480	2.279	2.197	-15	2.623	1.614
10	-452	1.387	2.480	2.279	2.197	-15	2.623	1.614
11	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
12	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
13	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
14	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
15	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
16	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
17	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
18	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
19	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
20	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
21	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
22	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
23	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
24	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
25	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
26	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
27	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
28	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
29	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
30	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
31	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
32	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
33	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
34	-391	1.869	3.148	2.800	2.762	804	3.216	2.202
35	-391	1.869	4.615	4.266	2.762	804	9.216	8.202
IRR			37,98%	34,92%	146,46%	10,50%	5,18%	2,54%

Hypothesis 3. NPV calculation for table grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		-1.723	-8.323	-7.892	-3.223	-4.223	-49.723	-49.723
1	-427	1.310	2.341	2.151	2.074	-15	2.476	1.524
2	-402	1.236	2.209	2.029	1.957	-14	2.336	1.438
3	-380	1.166	2.084	1.914	1.846	-13	2.204	1.357
4	-358	1.100	1.966	1.806	1.741	-12	2.079	1.280
5	-338	1.038	1.855	1.704	1.643	-12	1.961	1.207
6	-319	979	1.750	1.607	1.550	-11	1.850	1.139
7	-301	924	1.651	1.516	1.462	-10	1.746	1.075
8	-284	872	1.557	1.431	1.379	-10	1.647	1.014
9	-268	822	1.469	1.350	1.301	-9	1.554	956
10	-253	776	1.386	1.273	1.228	-9	1.466	902
11	-206	986	1.659	1.475	1.456	425	1.695	1.161
12	-194	930	1.566	1.392	1.374	401	1.599	1.095
13	-183	877	1.477	1.313	1.296	378	1.509	1.033
14	-173	828	1.393	1.239	1.222	357	1.423	975
15	-163	781	1.314	1.169	1.153	336	1.343	920
16	-154	737	1.240	1.103	1.088	317	1.267	867
17	-145	695	1.170	1.040	1.026	299	1.195	818
18	-137	656	1.104	981	968	282	1.127	772
19	-129	618	1.041	926	914	266	1.064	728
20	-122	583	982	873	862	251	1.003	687
21	-115	550	927	824	813	237	947	648
22	-109	519	874	777	767	224	893	612
23	-102	490	825	733	724	211	842	577
24	-97	462	778	692	683	199	795	544
25	-91	436	734	653	644	188	750	513
26	-86	411	692	616	608	177	707	484
27	-81	388	653	581	573	167	667	457
28	-76	366	616	548	541	158	630	431
29	-72	345	581	517	510	149	594	407
30	-68	326	548	488	481	140	560	384
31	-64	307	517	460	454	132	529	362
32	-61	290	488	434	428	125	499	341
33	-57	274	461	409	404	118	470	322
34	-54	258	434	386	381	111	444	304
35	-51	389	746	665	505	251	1.345	1.213
NPV	-6.120	22.003	32.766	29.183	32.833	1.563	-6.508	-21.174

Hypothesis 3. Table grape PP and Cash flow calculation

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0ºC	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2ºC	- 5ºC
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		-1.723	-8.323	-7.892	-3.223	-4.223	-49.723	-49.723
1	-452	-334	-5.841	-5.612	-1.025	-4.239	-47.098	-48.107
2	-904	1.055	-3.359	-3.332	1.174	-4.254	-44.473	-46.492
3	-1.357	2.444	-878	-1.052	3.372	-4.270	-41.849	-44.876
4	-1.809	3.833	1.604	1.228	5.571	-4.285	-39.224	-43.260
5	-2.261	5.222	4.086	3.508	7.769	-4.301	-36.599	-41.644
6	-2.713	6.611	6.568	5.789	9.968	-4.316	-33.974	-40.029
7	-3.166	8.000	9.050	8.069	12.166	-4.332	-31.349	-38.413
8	-3.618	9.390	11.532	10.349	14.365	-4.348	-28.724	-36.797
9	-4.070	10.779	14.014	12.629	16.563	-4.363	-26.099	-35.181
10	-4.522	12.168	16.495	14.909	18.762	-4.379	-23.475	-33.565
11	-4.914	14.039	19.646	17.710	21.526	-3.573	-20.257	-31.362
12	-5.305	15.910	22.796	20.511	24.290	-2.766	-17.039	-29.158
13	-5.696	17.781	25.946	23.312	27.054	-1.960	-13.821	-26.954
14	-6.087	19.652	29.096	26.112	29.818	-1.154	-10.603	-24.751
15	-6.478	21.524	32.246	28.913	32.581	-348	-7.385	-22.547
16	-6.869	23.395	35.396	31.714	35.345	458	-4.168	-20.343
17	-7.260	25.266	38.546	34.515	38.109	1.264	-950	-18.140
18	-7.651	27.137	41.697	37.316	40.873	2.071	2.268	-15.936
19	-8.042	29.008	44.847	40.117	43.637	2.877	5.486	-13.732
20	-8.433	30.879	47.997	42.918	46.401	3.683	8.704	-11.529
21	-8.824	32.751	51.147	45.718	49.165	4.489	11.922	-9.325
22	-9.215	34.622	54.297	48.519	51.929	5.295	15.139	-7.121
23	-9.606	36.493	57.447	51.320	54.693	6.102	18.357	-4.918
24	-9.997	38.364	60.597	54.121	57.456	6.908	21.575	-2.714
25	-10.388	40.235	63.747	56.922	60.220	7.714	24.793	-510
26	-10.779	42.107	66.898	59.723	62.984	8.520	28.011	1.693
27	-11.170	43.978	70.048	62.523	65.748	9.326	31.228	3.897
28	-11.561	45.849	73.198	65.324	68.512	10.132	34.446	6.101
29	-11.952	47.720	76.348	68.125	71.276	10.939	37.664	8.305
30	-12.343	49.591	79.498	70.926	74.040	11.745	40.882	10.508
31	-12.734	51.462	82.648	73.727	76.804	12.551	44.100	12.712
32	-13.125	53.334	85.798	76.528	79.568	13.357	47.318	14.916
33	-13.516	55.205	88.949	79.328	82.331	14.163	50.535	17.119
34	-13.907	57.076	92.099	82.129	85.095	14.969	53.753	19.323
35	-14.298	58.947	95.249	84.930	87.859	15.776	56.971	21.527

Hypothesis 3. IRR calculation for table grape production

	Irrigation				Altitude		UV net	
Adaptation measure	NO	Furrow 0 m / 0°C	Drip 160 mm	Drip 120 mm	+250 m	+500 m	- 2°C	- 5°C
	SC 0	SC 1	SC 2	SC 3	SC 2	SC 3	SC 2	SC 3
0		-1.723	-8.323	-7.892	-3.223	-4.223	-49.723	-49.723
1	-452	1.389	2.482	2.280	2.199	-16	2.625	1.616
2	-452	1.389	2.482	2.280	2.199	-16	2.625	1.616
3	-452	1.389	2.482	2.280	2.199	-16	2.625	1.616
4	-452	1.389	2.482	2.280	2.199	-16	2.625	1.616
5	-452	1.389	2.482	2.280	2.199	-16	2.625	1.616
6	-452	1.389	2.482	2.280	2.199	-16	2.625	1.616
7	-452	1.389	2.482	2.280	2.199	-16	2.625	1.616
8	-452	1.389	2.482	2.280	2.199	-16	2.625	1.616
9	-452	1.389	2.482	2.280	2.199	-16	2.625	1.616
10	-452	1.389	2.482	2.280	2.199	-16	2.625	1.616
11	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
12	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
13	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
14	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
15	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
16	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
17	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
18	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
19	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
20	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
21	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
22	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
23	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
24	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
25	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
26	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
27	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
28	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
29	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
30	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
31	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
32	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
33	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
34	-391	1.871	3.150	2.801	2.764	806	3.218	2.204
35	-391	2.991	5.737	5.108	3.884	1.926	10.338	9.324
IRR		80,69%	30,38%	29,39%	68,31%	7,65%		2,40%

Annex 5. AGRICULTURE IRRIGATION

According to the State Statistical Office of Macedonia's Census of Agriculture 2007, only 29.72% of farmers (57,185 farmers out of 192,378) own irrigation equipment. In total, around 70% of farmers have access to irrigation.

Irrigation access by farmers

	Number of farmers irrigate	Total number of farmers	Share of access to irrigation
Vardar Region	14.141	23.287	61%
East Region	16.717	27.795	60%
Southwest Region	16.439	21.412	77%
Southeast Region	20.097	25.978	77%
Pelagonia Region	17.933	27.578	65%
Polog Region	21.850	25.632	85%
Northeast Region	12.494	21.631	58%
Skopje Region	11.565	19.065	61%
Republic of Macedonia	131.236	192.378	68%

The total area of land covered with the irrigation scheme is 69,070 ha. The Southeast Region has the largest area under the irrigation system, at 12,234 ha.

Land irrigated by farmers in ha

	Vardar Region	East Region	Southwest Region	Southeast Region	Pelagonia Region	Polog Region	Northeast Region	Skopje Region	Republic Macedonia
Cereals	1.569	4.651	2.121	3.057	2.255	5.903	3.803	1.002	24.360
Industrial	337	274	146	1.350	1.871	288	162	107	4.534
Vegetable	1.135	1.291	783	4.589	2.475	1.732	1.309	2.184	15.499
Fodder	769	327	1.016	599	454	701	351	172	4.389
Orchards	1.032	368	486	702	2.659	328	138	195	5.908
Vineyards	6.071	172	46	1.749	176	37	58	158	8.467
Meadows	162	387	766	86	521	2.144	93	118	4.277
Other	107	202	191	102	173	578	107	174	1.635
Irrigated	11.183	7.672	5.555	12.234	10.585	11.711	6.020	4.110	69.070

The area of irrigated land is very low. While almost 70% of farmers have access to irrigation, only 26% of the used land is irrigated. This is mainly the result of the extensive parcelization of the land owned.

The total used land is separated into 636,911 parcels, which means that the average size of a used plot is 0.42 ha.

Irrigation coverage

	Vardar Region	East Region	Southwest Region	Southeast Region	Pelagonia Region	Polog Region	Northeast Region	Skopje Region	Republic Macedonia
Cereals	13%	23%	28%	27%	9%	49%	15%	9%	20%
Industrial	33%	40%	486%	34%	25%	342%	32%	20%	31%
Vegetable	65%	47%	82%	71%	84%	84%	66%	70%	70%
Fodder	49%	21%	31%	17%	14%	16%	18%	8%	20%
Orchards	89%	22%	55%	69%	86%	65%	22%	44%	63%
Vineyards	59%	17%	13%	58%	31%	44%	6%	20%	49%
Meadows	14%	7%	16%	7%	9%	37%	2%	5%	14%
Other	2%	3%	9%	6%	5%	34%	2%	13%	7%
Irrigated	34%	19%	28%	38%	21%	44%	15%	19%	26%

Vegetable production and orchard farming have the highest irrigation coverage. Only 20% of cereals production is irrigated.

Irrigation coverage according to land usage and region